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SOCIETY OF MOTION PICTURE ENGINEERS

Transactions
Number 1
1916

(See index to v. 1-16, 1916-23)

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SOCIETY OF MOTION PICTURE ENGINEERS

Transactions
no. 1
1916

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INCORPORATION AND BY-LAWS

C. FRANCIS JENKINS
TEMPORARY CHAIRMAN
WASHINGTON, D. C.

HERBERT MILES
TEMPORARY SECRETARY
NEW YORK CITY

1916

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CERTIFICATE OF INCORPORATION

SOCIETY OF MOTION PICTURE ENGINEERS

The undersigned persons, all of legal age and citizens of the United States, desiring to associate themselves for certain purposes stated herein, do now here make, sign and acknowledge this certificate of incorporation.

First. The name by which this corporation shall be known in law is "SOCIETY OF MOTION PICTURE ENGINEERS."

Second. The term for which this incorporation is organized is perpetual.

Third. The particular business and objects of this corporation are for the promotion and advancement of the motion picture art, and for mutual benefit.

Fourth. The number of trustees, directors, managers or governors of this corporation for the first year of its existence shall be seven.

Fifth. The said corporation shall have the power for themselves and their successors to have and use a common seal, and alter and change the same at pleasure, and make by-laws and elect officers and agents, and take, receive, hold and convey real and personal property, and do such other things as may be necessary or desirable for the purposes of this corporation.

In testimony whereof, we have hereunto set our hands on the 24th day of July, A. D. 1916.

C. FRANCIS JENKINS,	Washington, D. C.
DONALD J. BELL,	Chicago, Ill.
PAUL H. CROMELIN,	New York City.
C. A. WILLATT,	Boston, Mass.
FRANCIS B. CANNOCK,	New York City.
W. BURTON WESTCOTT,	Boston, Mass.
PAUL BROCKETT,	Washington, D. C.
E. KENDALL GILLETT,	New York City.
HERBERT MILES,	New York City.
J. P. LYONS,	Cleveland, Ohio.

Personally appeared before me the above subscribers, who severally acknowledged the same to be their act and deed for the purposes therein set forth.

Witness my hand and official seal this 24th day of July, A. D. 1916.

(Signed) RALPH S. SHERLINE,
Notary Public.

(Seal.) My commission expires January 4, 1920.

CONSTITUTION AND BY-LAWS

Name.

1. The name of this association shall be SOCIETY OF MOTION PICTURE ENGINEERS.

Objects.

2. Its objects shall be: Advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

Membership.

3. The membership of the Society shall consist of Pioneer Members, Honorary Members, Active Members, and Associate Members. A Pioneer Member is defined as one who was in the art as a principal fifteen years or more antedating the time of the organization of this Society; an Honorary Member as one who has been actively engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts for more than ten years; an Active Member as one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts; and an Associate Member as one who, though not eligible to membership in the active class, is interested directly in the art.

Eligibility.

4. Any person of good character may be a member in any or all classes to which he is eligible.

5. Prospective members shall be proposed in writing by at least two members in good standing, and may be elected only by the unanimous vote of the Board of Governors. Valid autographed ballots may be forwarded by absent members of the Board of Governors.

Applications.

6. All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

7. The entrance fee shall be twenty-five dollars ($25.00). The annual dues for Active Members shall be ten dollars ($10.00), payable in advance on July 1st of each year.

The annual dues for Associate Members shall be five dollars ($5.00), payable in advance on July 1st of each year.

The dues for Pioneer Members shall be $250, and its payment exempts the member from all future dues.

The dues for Honorary Members shall be $100, and its payment exempts the member from all future dues.

Officers.

8. The officers of the Society shall be a President, two Vice-Presidents, a Secretary, a Treasurer, and a Board of seven Governors, who shall be elected to their respective offices at the October annual meetings by a majority of autographed ballots of the members, and counted by a committee of tellers appointed by the President. All officers shall hold office for one year or until their successors are chosen, except the Board of Governors, as hereinafter provided, and the Vice-Presidents; one of whom latter-named shall be elected for two years and one for one year, and then one for two years, each year thereafter.

Governors.

9. The Board of Governors shall consist of the President, the Secretary, and the Treasurer, *ex officio,* and four active members; two of which last-named shall be elected for a two-year term and two for one year, and then two for two years, each year thereafter.

Duties.

10. The duties of the several officers are those usually appertaining to each such office, together with such additional duties as may be prescribed by the Board of Governors.

The Treasurer shall be bonded in an amount to be determined by the Board of Governors.

Meetings.

11. The regular meetings of the Society shall be held in such places and at such hours as the members may have designated at the preceding meeting. A quorum shall consist of twenty-five or more voting members. Special meetings may be called by the Board of Governors when necessity therefor arises. Active Members only shall be entitled to vote. The Board of Governors shall meet quarterly at such time and place as they may select. Special meetings may be called by the President when occasion requires, or upon the request of any three members of the Board of Governors, not including the President.

Publications.

12. All matters of general interest deemed worthy of permanent record shall be published in serial volumes as soon as possible after each regularly called Members' meeting. A copy shall be mailed each member in good standing to his last address of record. Extra copies shall be printed for general distribution, and may be obtained of the Secretary on the payment of a fee fixed by the Board of Governors.

Emblem.

13. The emblem of the Society shall be a facsimilie of a six-hole film-reel, with the letter S in the upper center opening, and the letters M, P and E in the lower three openings, respectively. The Society's emblem may be worn by members only.

Delinquents.

14. Members who are in arrears of dues for thirty days after notice of such delinquency, mailed to their last address of record, shall have their names posted at the Society's headquarters, and notices of such action mailed them; and thirty days after such posting the member shall be dropped from the rolls if such non-payment has continued.

Suspension.

15. Any member may be suspended or expelled for cause by a four-seventh vote of the Board of Governors; *provided,* he shall be given due notice and a copy in writing of the charges preferred against him and shall be afforded opportunity to be heard ten days prior to such action.

Amendments.

16. These by-laws may be amended, altered or added to at any regularly called Members' meeting on a two-thirds vote by ballot of the members present at that meeting.

STANDARDIZATION

ADDRESS BY HENRY D. HUBBARD, SECRETARY, U. S. NATIONAL BUREAU OE STANDARDS, BEFORE THE SOCIETY OF MOTION PICTURE ENGINEERS, AT ITS WASHING-TON MEETING, MONDAY, JULY 24, 1916

Your appreciation of standardization is evident since you give it first place on your program. Standardization is too big a theme to be lightly regarded, and its possibilities have already aroused an enduring interest among engineers everywhere. For fifteen years your National Bureau of Standards has seen the rapid rise of this subject in so many lines that a list would be too long to read here. I may here touch only upon a few thoughts of appreciation of your work and the application of the theme to the motion picture field,—a subject which stimulates our imagination and kindles our enthusiasm.

Standardization is a big word, almost as broad as civilization, for our manners and customs are merely accepted standards of conduct, our laws aim to standardize human relations, and daily life is governed by standards approved by common consent. Standardization is more than a passing fancy of efficiency experts. It thrives everywhere, often against efforts to prevent. Our daily life has its time schedule. Work and recreation are run by the clock, and if we would be efficient we must fit nicely into the standardized time schedules. Diet experts standardize the food requirement for proper growth, activity, and repair of our body. We may judge by comparison with normal body size and weight whether we need development, and from our respiration, heart beat, and temperature whether vitality is normal. These things are so standardized that they are the foundation of physical diagnosis.

Coinage, weights and measures, and time are standard. Business organization is being standardized. So, too, is transportation, manufacturing, and machinery. The motions of the workers are being studied in order to standardize his movements along the lines of least effort. In this personal motion economy with its possibilities for human welfare the motion picture is the indispensable means of research.

Everywhere we feel the urge for standardization. It calls for normal regime, normal equipment, normal efficiency. Our clothing is standardized, and though no law prevents, we would not care, for example, to come here this morning without a necktie, for society enforces its standardization by social pressure stronger than law. Our every garment is standard in size and cut, and we must fit into the staple sizes or pay made-to-order prices. Our streets, houses, and rooms are of standard types, as are our furniture, utensils,

books, magazines, and newspapers. Staple sizes, standard grades, set routine are all part of the big machine process into which human activity and equipment are being fitted, with happily increasing emphasis on the health, comfort, and happiness of the individual. Each profession aims to standardize its training, its terminology, its equipment, its data, both numerical and descriptive, its code of ethics, and to fix standards of quality and performance,—showing that standardization has a breadth commensurate with human activity.

A simple example of standardization is the orchestra. The instruments are of standard size and form, and when played together they must be standard as to performance, that is, tuned to a definite pitch, say 435 vibrations per second for alto A. If the pitch is standard, instruments shipped to any part of the world will harmonize with local instruments tuned to standard pitch. Here standardization is simple—a single number and the unit of time.

Measurement is the heart and soul of standardization. The optician with his standards can adapt the measured curvature of the lens to correct the measured defect of the eye. In a structure measured strength must fit measured stress, as a glove fits the hand. We now measure not the size alone but the quality as well, for quality is as truly a test of fitness as size. Each property must be of right magnitude and the group of properties must be proportioned and combined to fit the uses to be served as the contour of a key is shaped to fit the recesses of the lock. For quality is not a vague intangible property. It consists of a group of definite properties, each having a distinctive magnitude. The combination fixes the specific quality and may be specified in terms of measurement. If each property in the material is given a numerical magnitude in terms of units of measure, we have set a standard for the material and are enabled to measure its quality. The pertinent properties are separately measureable and this gives us the means to control quality.

Standardization must be built upon the solid rock of science, for science is standardized knowledge. Noble examples of standardization are found in history, but only recently has it come into flower in a manner that is transforming our standards of progress. Standardization is not, however, a transitory stage to be passed through. Far from it. It is to be a continuous enterprise. Its function is nothing less than the conscious control of mechanical evolution. Chance has hitherto played such a role that a new era is reached when we unite to standardize progress. Standardization must imply progress. As long as progress is possible, standardization must be free to grow apace with science. If it means fixity we should avoid it, for fixity in a progressing civilization is an anachronism. Steady progress through standardization is the true aim. Such standardization should unite two elements—the tendency to conserve progress and the pressure for new progress. These two tendencies do not conflict if we avoid the usual tendency to let the good become the enemy of the best. No value is lost if we keep the good only until

the better way is shown. Standardization of this kind is the steady harvesting of progress.

Interchangeability of parts is an important principle of standardization, but more important is this implication that a true standardization is the consensus of the best as far as that is practically attainable. To bring things to a dead level of uniformity at an arbitrarily fixed value is not standardization at all. Standardization means and implies an ideal to be realized. Ideal standards therefore involve searching investigations so that they may be based upon scientific principles rather than on empirical judgment. In many cases, even yet, tentative standards alone are possible. Standardization is at its best only when each magnitude of property or dimension is found by theory and test to be the most fit for its use. Such standardization is a continuous development, not a thing to begin with but to arrive at. Like the bark of a tree, standardization may bound progress but must not limit growth. Inflexible standards are liable to retard progress so that we must keep before us the ideal that at any time the standards must be the consensus of the best, scientifically formulated.

Motion picture engineering presents a splendid field for standardization. The need is obvious, for your machines and films travel to all parts of the world, and the demands of human safety, human vision, and comfort are common to all men in all lands. An ideal picture presentation for one is an ideal for others, since human nature is much the same the world over, and since mother nature standardized the human eye ages ago.

Cooperation is implied in the fact that you are organized. Stable standardization is that in which all concerned are represented and their interests regarded—engineer, maker, and user. To overlook any factor is to vitiate the standardization as time will show. It is the business of the engineer to bridge the gap between the maker and user. The user, however, is the final dictator in standardization and his satisfaction is a practical test of quality. It is wise to recognize this fact at the outset and secure the continued cooperation of the engineer, maker, and user.

Much has been done in planning place, equipment, and process in your field, but as elsewhere much remains for scientific research to determine by experiment the best principles of design and operation. Where the best is not scientifically known and where interchangeability or large scale production are not controlling factors, then standardization should be freer—the performance standard being set to allow play to individual design and trial in service.

Some of your standardization problems are pressing, others look to the future. Several examples may be given. You have the problem, for instance, of seating for comfort, for space economy, and for effective seeing. This standardization would, perhaps, fix the best form and size of seats, their location, the minimal seating distance from the screen, and the minimal angle of the observer's line of sight with the plane of the screen. Seating thus involves

comfort and good seeing—factors which affect the patronage. These are obvious examples, but they should be handled as scientific problems and not settled by personal opinion. Science alone can give the needed impersonal basis for such standards.

Your nomenclature is an important subject for standardization. New machines, new processes, new materials appear, to which new names are given, some of them apt and striking. They are real contributions to our language and should have standard definition. So, too, all the terms of the industry should be clearly named, and officially defined in the interest of definiteness and to avoid misunderstandings. The dictionary must follow usage and cannot really standardize. It is rather a dragnet for all usages and meanings. The standardization of terminology should be by the primary users of the terms employed and will greatly facilitate definite thought and discussion.

Optical standardization would include light sources in the studio and the theater—their quality, steadiness, brightness, and distribution; also the optical systems of lenses, reflectors, screens, and the question of eye comfort. For example a standard studio light might be specified and perhaps scientifically planned to eliminate glare by absorbing screens while retaining a standard photochemical action. Clearly the film sensitivity, the studio light, and the projection lantern must be standardized upon the same basis if the outcome is to be successful. The best exposure and projection time of unit picture in relation to light intensity and retinal persistence is a matter for physical and psychological experiment. Among the most obvious items to be standardized are the width, length, and thickness of the film; the form, size, and location of the perforations, and such standardization to be stable must be on a world basis, for science is international and scientific standardization must be the same.

Looking more to the future, an ideal we are approaching slowly, and in which engineers should take a deep interest, is that of an ideal atmosphere within the theater. It is a problem of hygiene to ascertain numerically the factors needed by the engineer to provide such a standard ideal atmosphere. It may eventually include the best temperature, abundant fresh air, and also the cooling and drying of the air when required, making it dust free, circulating it, and possibly giving it a healthful trace of ozone, and the fragrance of the woods. This may be looking a long way ahead, but vision is required in such matters. When we speak of a standard indoor climate, we may recall that practically all of these elements have been separately realized in actual service and need but the unifying hand of the engineer to realize in combination. What this standard atmosphere will mean for public health, comfort, and enjoyment can hardly be overestimated.

Your motion picture industry touches many arts—photography, architecture, illumination, the drama—and it would be needless to suggest how varied are the subjects which involve standardization.

I am sure you appreciate that standardization stands not for fixation, but for steady progress, step by step, at such time intervals as may be found most efficient. In your work, as in that of other societies of engineers, you may count upon the cooperation of the National Bureau of Standards. On behalf of Dr. Stratton, the Director of the Bureau, I may say that the facilities of the Bureau as far as practicable will be extended to any committee you may appoint to deal with standardization.

In conclusion, may I express my deep appreciation of your work and the art it serves. To me the motion picture is the wonder of the world in its effects and possibilities. Its uses in education, science, recreation, industry, engineering, and social movements make it vie in interest and power with the printing press itself. It speaks the universal language of action. It is the magic carpet of Bagdad to take us to all lands, under sea and under land, among the clouds, to fairyland, and into the world's markets, laboratories, hospitals, and factories. In portraying the flight of a bullet it magnifies time, in recording the unfolding of a flower from the bud it compresses days into seconds. It is not making the world a little neighborhood, it is rather making of each neighborhood a little world. It intensifies life by broadening its contact with all life—for it is your business to bring into the experience of each the experience of all. Through the motion picture, in fact, we may create new experience, for nowhere has the magic of the miraculous been so tangibly realized as on the screen. The quickening effect of this wonderful art upon social evolution is beyond estimate. To say that as an art it is in its infancy is to state the obvious. Its possibilities are limited only by the power of the creative imagination and the technical powers of the engineer. Its success depends not upon subject alone but upon the factors of economy, efficiency, safety, comfort, and interest, which in turn depend upon scientific standardization. May your work have a success commensurate with its interest and importance, and through your organization may you, in the words of Washington, "raise a standard to which the wise and the honest can repair."

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

MEETING *of* OCTOBER 2-3, 1916

HOTEL ASTOR
NEW YORK CITY

NUMBER TWO

TWENTY-FIVE CENTS

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SOCIETY OF MOTION PICTURE ENGINEERS

RESULT OF ANNUAL ELECTION
OCTOBER, 1916

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WASHINGTON, D. C.

Vice President

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Vice President

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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers is a marked distinction. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts; and an Associate Member is one who, though not eligible to membership in the active class, is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least two members in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee (for both Active and Associate Members) shall be twenty-five dollars ($25.00). The annual dues for Active Members shall be ten dollars ($10.00), payable in advance on July 1st of each year. The annual dues for Associate Members shall be five dollars ($5.00), payable in advance on July 1st of each year.

CHAIRMAN'S ADDRESS

FELLOW ENGINEERS:

Those of you who missed attendance on the Washington meeting missed much. I know from the spirit shown at that meeting, and from the character of the gentlemen who attended, some of them coming from Chicago, some from New York, from Boston, and Cleveland, that this Society was formed with an honest intent to be of service to the industry at large; and that the officers and members alike intend to give largely of their time and energy for the promotion of the general good and without thought of financial reward; and as the engineer stands behind it all, we should feel due responsibility, while taking justifiable pride in our vocation.

The motion picture is making the whole world kin. It speaks the only universal language, understood by the illiterate of every tongue as easily as by the learned, and is rapidly tending toward tolerance in world thought. It not only shows us our distant neighbor, but also shows us ourselves as he sees us. It is making of the world one great family, and soon we will come to feel that we are a friend of the man over yonder, because we know him so well from seeing him in the picture so often.

Every new industry standardizes sooner or later, whether we will it or not. It is our duty, therefore, as engineers, to wisely direct this standardization, to secure best standards of equipment, quality, performance, nomenclature, and, unconsciously, perhaps, a code of ethics. It is entirely a practical and attainable ideal. But we should recognize our responsibility to fix standards with due regard for the interests of all concerned. It is an unselfish exchange of views which will make our gatherings interesting, and the discussions of individual investigation valuable.

Fortunately, one of the factors of our industry is already standard, the film. In this it is unique, for motion picture film is the only thing that is standard the world over. This it is that has given us the world as a selling field, and doubtless accounts very largely for the extraordinary growth of our business.

For that very reason our Society should represent more than just an association. Co-operation is all very well, but may be an entirely selfish bond, though this is sometimes temporarily necessary for self-preservation. But due regard for the rights of others reflects a gentleman in the mirror of our friend's countenance when we meet. Only under such unselfish circumstances can we ever expect to arrive at enduring standards in our art.

Let us, therefore, give of our best as we work at our craft. Let us each be truly American, known the world over as the man who, when's he's out for money doesn't mind work, when he's out for pleasure doesn't mind money, but when he is out for a principle doesn't mind either.

C. FRANCIS JENKINS.

PRECISION, THE DOMINANT FACTOR IN MOTION PICTURE MACHINES

W. B. WESCOTT
Boston, Mass.

MR. CHAIRMAN—GENTLEMEN:

We, in this body, will undoubtedly spend much time and thought on standards, and it seems to me that a cursory survey of the most important of these standards would be pertinent at this time—especially in their relation to each other, and the allowable departure from the standard; that is in the precision measure of the standard.

I think that you will agree that the final criterion of all motion picture standards is to be found *in the Picture on the Screen.* Hence, we may confine our efforts at standardization to those elements in which departures from a precise standard affect, directly or indirectly, our clear, steady picture on the screen. For instance, let us examine whether or not we shall consider for standardization the projector-magazine-reel spindle. Certainly;—because after all the evils of spindles, such as being out of true, too small, etc., are lightly passed over, and if I am not mistaken there are those of us who have something definite to say about this same reel-bearing-spindle; there may be seen on the screen the effects of a wobbling, heavy reel—the vertical vibration of the picture may be due in part to this,—the lateral vibration due to damage to the film edge by the unsteady reel,—scratches due to ripping when toward the last of the reel, there are sudden and violent changes in an already high angular velocity. Therefore, this spindle is worthy of a standard and the list of vital parts to be standardized is a long one.

We will find as we go down the list of elements that function toward the final picture, that *most* of them should conform to some standard—that there is *one* shape, size, position, relation or speed which results in *least action;* that is, produces the desired effect with satisfactory precision at a minimum expense of energy, material, space or wear.

But we will find that the precision measure of the standards will vary probably from element to element. For instance, our taking lenses should have at full aperture, as high a resolving power as possible, but not less than the lower limit of our standard; while with our present condenser systems, a more highly corrected lens than the usual projection objective will not show a marked improvement in definition on the screen. Then, for our taking lens, the standard must have much narrower limits than those permissible for our standard of projection objective.

And again, it is obvious that in the matter of projection machine aperture we have much greater latitude than we have in, say, the intermittent mechanism which positions, at this aperture, the image

to be projected. But inasmuch as these various standards will all come up for our consideration, each in its own good time, I need not enlarge further along this line.

Some of these standards will be found to be determined by custom, economy, or any of the many obvious considerations, while others will not be matters of choice at all, but will be derived from other standards.

Those standards which are matters of choice may be anything you please; such as three sprocket holes to the picture if you wish, and think you can make the innovation attractive to the majority. This is purely a matter of expediency. But the precision limits of these sprocket holes is not a matter of choice. Their size, shape and position in relation of the dividing line—choice again, but not the *amount* of *vibration* in the size, shape or position.

The variations in size may have a certain precision limit along one axis, and a precision limit of a whole order higher along the other—the length of the sprocket hole might vary by as much as plus or minus 1/1,000th of an inch; while a plus or minus variation of 1/10,000th of an inch in the width of the sprocket hole might produce a disturbing effect on the screen. And then again there are important and involved relationships which will prove to be of moment in the determination of precision limits. For instance, take the case of a mechanic's scale as a standard of linear measure, and even though it has suffered abuse it is still good enough as a standard with which to measure say, a few lengths of gas pipe—a low order of precision is perfectly satisfactory here; but if this same scale were to be used to measure the change in length of a short piece of film, with the change in grains of water per cubic foot of air, then it would be necessary to know at what temperature the scale was standard; and if used at any other temperature, its coefficient expansion, that corrections could be made to compensate for the scales departure from standard. It is important that this involved relationship should be borne in mind when considering the precision limits of standards.

But who then, is to determine these important precision limits and how? I do not mean the standards—some are still matters of choice—others are irrevocably fixed by custom, while still others will be found to be fixed by the requirements of their precision limits.

Gentlemen, there is one standard of transcendental importance, and when we have once defined it, then any of us can satisfy himself as to the precision limits of any other standard suggested, by the mere expedient or performing a few simple sums in arithmetic. But until this supreme standard is defined, no concordant precision relationship between such standards as there may be, can be hoped for.

Take the matter of projection speed—in any terms you like, such as pictures per second, feet per minute—intermittent R. P. M.—they may all be converted into the number of phase pictures presented to the eye in unit time. If there is no phase difference, that is no motion of the object photographed, then so far as the spec-

tator is concerned, the projection speed may be zero, for he sees a still, anyway.

A standard of projection speed, it is perfectly obvious, must depend, in general, on the average angular speed by the lens of subjects photographed; and this angular speed by the lens will depend on the length of exposure and on the standard of definition—circle of confusion—which, like the house that Jack built, will depend on one of the limits of our *supreme* standard—*The Picture on the Screen.*

Set a standard for the picture on the screen, and the precision limits of all your important standards are determined.

For some of the defining terms of our standard picture on the screen, it would seem necessary to consult individual opinion, but fortunately, for a few only.

From an extended statistical study it may be possible to ascertain to the satisfaction of the majority, the most important factor of all. *The position of the standard spectator in relation to the screen.* And our standard picture on the screen must be defined for the satisfaction of our standard spectator. For instance, it is more important that we know the angle subtended by the picture at the eye of the standard spectator, than that we know the size of the picture in feet, or even in projection aperture diameters, or the angle subtended by the picture at the projection objective; for whether or not lack of precision anywhere in the system will be apparent—not on the screen—but to the standard spectator, will depend in the main, on the angle of the spectator's view subtended by the picture on the screen. A moment's consideration will show that the same limits hold whatever the spectator's angular view of the screen picture is the same. This is to say that the same percentage change will produce the same effect where the picture is small and the spectator near, or the picture large and the spectator at a distance, so long as the picture occupies the same fraction of the spectator's field of view. And this will hold for any factor when the other factors are a constant.

Therefore, in order to build up a system of standards for the Motion Picture industry which shall be concordant, we must define and limit our standards, however they may be determined, in terms of precision measure—a percentage allowable variation. And to determine this *all-important precision measure* for any standard, we must refer to the picture on the screen as viewed by a standard spectator.

MOTION PICTURE FILM PERFORATION

DONALD J. BELL
Chicago, Ill.

My reference to Cine-machinery is intended to broadly cover all machinery used for the manufacture, assembling and projection of motion pictures, and I shall endeavor to briefly present my conclusions in reference to Standardization of perforations of Motion Picture Film.

For many years it has been my belief that there should be a concerted effort to bring about a meeting of designers and manufacturers of cinema apparatus so that this very important matter could be discussed by those who appreciate the far-reaching benefits that Standardization will bring to the motion picture industry.

Undoubtedly, all who are engaged in this line of endeavor have wished for a fixed standard to follow, but there has been no bringing together of designers and heads of the various departments of motion picture manufacturing establishments or those who direct the development and manufacture of projecting apparatus. Now, our genial friend—C. Francis Jenkins—has taken the initiative and by his invitation we are here to form the Society of Motion Picture Engineers.

I am sure we are all grateful for the opportunity that is now offered us and have come to New York City with a feeling of pleasure because we shall have the opportunity to lend our aid to the advancement of the Cinematographic Art. The invitation to join with you gentlemen as a charter member gives me great pleasure and I assure you that my humble efforts will be given happily and to the fullest extent of my understanding.

My present concern and greatest interest is—as you may infer from my previous remarks—STANDARDIZATION.

My first experience in this line of endeavor was employment as an operator—my employment beginning about May, 1897. The work had a great fascination for me. My ideas at first may have seemed to be only dreams to others, still I steadfastly maintained that it would not be long until motion pictures would cease to be a novelty, but were bound to become a greater factor in scientific research and educational effort, and to take a very important place among amusement enterprises. So, gentlemen, I decided to make this my life work and to gain an understanding of the subject that would win for me the respect of those engaged in the art of motion picture production.

As I gained experience and knowledge in the art of projection, my thoughts turned to the possibilities of improvement of the projecting apparatus I had in hand. My first efforts in designing showed me that it was a very difficult matter, indeed, to form a

projector so that perfectly steady control could be obtained when there were no standards to follow.

There seemed to be an endless variety of perforation gauges. Even the product of any certain maker of motion pictures showed a wide variation in distances between all centers, absolute uncertainty of spacing, and perforations of many varying forms.

Even one certain film subject would have all of the above characteristics. This made it necessary for all sprocket teeth to be machined so small that film of any or all variations would pass through the machine without damage.

As it was not practical to machine sprocket teeth or other means of control to closely fit into the sprocket holes of the film, it was found necessary to provide an extreme tension so that when the film came to the period of rest, it would remain in a fixed position, and on account of the variation of the position of the dividing line, it was necessary to provide means to bring the film in registration with the aperture as the various sections of the film came into position for projection. This means of adjustment was also necessary because the extreme tension on the film over the aperture caused a strain against the walls of the holes sufficient to cause tears, and a poorly made splice would often cause the film to leave the sprocket, which necessitated framing pictures many times during an exhibition.

These conditions still prevail, but I am happy to say in a far lesser degree than that of a few years ago.

There still is, however, a considerable variation in the products of various manufacturers, and I firmly believe that the first step toward standardization must be to establish what shall be the size and form and spacing of perforation.

In justice to the manufacturers of projecting apparatus, I must say that they now have provided a fixed standard, this being the diameter of the Intermittent Sprocket. Investigation shows this standard to be 15/16ths of an inch, and as this diameter appears to be in general use, it is well that this may be considered as a standard established and to be followed.

This standard gives a working basis on which we may determine what must be the distance between the centers of the perforations, both lineally and transversely, but before fixing these standard dimensions, we must consider the normal amount of shrinkage of film after development. We must consult the Laboratory Superintendents, and make thorough scientific tests to establish the normal amount of shrinkage of both length and width of film after being developed and dried. We then may establish standard lineal and transverse dimensions between centers.

The manufacturers of projectors do not appear to have established a standard distance between each series of sprocket teeth, but I believe they must look to the motion picture manufacturers to adopt a standard of perforation, so that they may have a guide

to follow in this particular, and for their guidance there must be a standard size and form of perforations.

The standard film perforating herein described was adopted only after long experience in building of motion picture machinery and the handling of film. As a suggested standard of measurements it departs from earlier standards only where it is necessary to do so in order to take into account the physical changes to which the film is subjected.

It is accepted as settled that the maximum shrinkage of motion picture film is .0937 inches per foot. Painstaking experiment warranted the conclusion—fully established by later experience—that a gauge length of 11.968 inches for 64 holes would insure the accuracy of perforation necessary to perfect results and at the same time make due allowance for shrinkage of the film.

The following computation shows why we adopt 11.968 inches instead of 12 inches as the standard for a perforation gauge measuring 64 holes:

Assuming the outside diameter of the sprocket wheel in all standard projecting machines to be 15/16 inches or .9375 inches, then;

The diameter of the sprocket being .9375 inches

The circumference of the sprocket is 2.94525 inches.

As standard motion picture film has an average thickness of .0065 inches the pitch diameter of the sprocket will be found to be .9375 inches plus .0065 inches, or .944 inches.

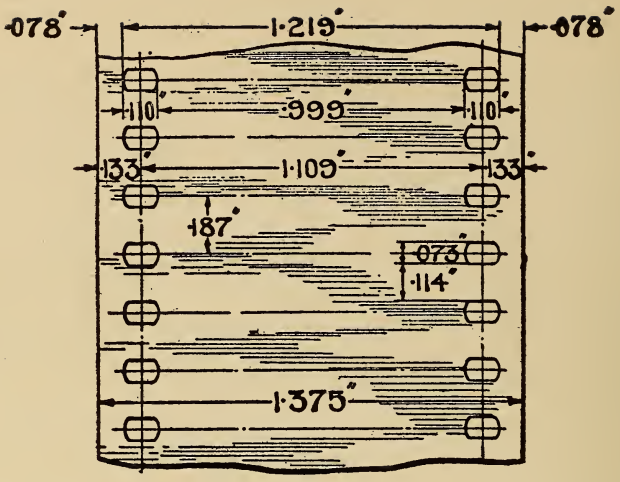
Pitch circumference is 3.1416 x .944 or 2.965704 inches. Circular pitch equal 2.965704 divided by 16 (the number of teeth to be found on the sprocket) or .1853—plus inches.

The standard perforating gauge being 11.968 inches for 64 holes and the maximum allowance for shrinkage of film being 3/32 inches or .0937 inches for 64 holes, therefore, 11.968 inches less .0937 inches or 11.8743 inches is the average length of shrunken film measuring 64 holes.

The pitch of the film or length per hole is 11.8743 inches divided by 64, or .18553 inches.

Pitch of sprocket, .1853 plus inches
Pitch of film, .1855 plus inches

The drawing shows the measurements by which the gauge is established; width of film over all 1.375 inches; width of film over all on perforation 1.219 inches; distance (width) center to center of perforations 1.109 inches; distance (width) inside to inside of perforations .999 inch; width of perforation .110 inch; distance (width) center of perforation to margin of film .133 inch; distance (width) outside of perforation to margin of film .078 inch; length of perforation .073 inch; distance (length) between perforations .114 inch; distance (length) center to center of perforations .187 inch.



With perforation, sprocket, dividing line and other standards effected, then within a reasonable time the manufacturers of projecting apparatus may conform their means of control to closely fit the standardized perforations, and I am sure the whole industry will profit to an almost unbelievable extent. Most certainly strong tension to effect registration may be eliminated and this will insure against damage of film and perfect projection may be obtained.

We may all be proud of the achievements of the American Manufacturers of Motion Pictures and apparatus for their making and projection.

Let us all join together and earnestly endeavor to set a standard of photographic and mechanical excellence that will be the standard of the world.

CONDENSERS, THEIR CONTOUR, SIZE, LOCATION AND SUPPORT

G. FRANCIS JENKINS
Washington, D. C.

Surprisingly little literature has been written on the subject of condensing lenses, and none at all with regard to their use in motion picture projecting machines. Investigators outside our own art have so far failed to observe that the problem is not the same in a motion picture projecting machine that it is in a stereopticon lantern, a difference resulting from the necessity for the use of a shutter with the motion picture projector.

I shall confine my remarks practically wholly to the problems of the illumination of the picture aperture of a motion picture projecting machine, and its result on the canvas, rather than to the subject, generally.

Condensing lenses are employed because it is practically impossible to illuminate the film directly. When we get a cold light it may perhaps be feasible, though this is debatable. But for the present, condenser lenses, for gathering the diverging rays of the luminant and converging them on the picture aperture, continue to be used.

Two lenses are usually employed in combination for the reason that to get the same gathering power with the same convergence in a single lens there would be too great a loss of light by reflection from the curved surfaces. So lantern makers usually take two plano-convex lenses and mount them with the curved surfaces together, which puts a flat side next the light source.

As a simple but rather interesting experiment showing the loss of light by reflection, hold up your next glass of water and try to look upward through the surface of the water at about 45° angle. You will not be able to see anything above the water until it actually touches the surface.

This total reflection phenomena is usefully employed in many ways, e. g., in engraving plants to reverse the picture for etching; in binoculars to give a large field and long-range-telescope in short, compact form; in periscopes to see without being seen; in the Graphoscope for mechanical simplicity and convenient operation.

But this same reflection when from the surface of a single condenser, is a very decided loss. For this reason it is usual to employ two lenses in a condenser system. The first lens, the lens next the source of light, an electric arc usually, is popularly described as gathering the diverging rays and paralleling them, the second lens then converging them on the aperture plate. Lenses of 6½ and 7½-inch focus are usually employed for short projection distances, with the arc lamp 2½ to 3 inches from the surface of the arc lens.

To parallel the light rays with these two lenses the arc should theoretically be 6½ inches from the lens. But this is not best, for at the closer position more than four times as much light at the aperture results. If the rays could be paralleled by the first lens, the arc lens, then the converging lens might be any distance away. Because the arc lens cannot do this, the second lens, the converging lens, is brought up close to the arc lens in order to catch as large a portion of the rays as possible and concentrate them on the picture aperture.

Authorities on lenses have heretofore recommended that these converging light rays cross in the center of the projecting lens, but their conclusions have been based upon the old lantern slide assembly which had the pictures just in front of the converging lens, and did not employ a shutter at all. Their recommendations are not, therefore, wholly applicable, nor is the arrangement proposed for the lantern the best for motion picture projecting machines.

It might be nearer right if we could get lenses made so that the shutter could cut across the rays at the narrowest part, that is, at the diaphragm location in the lens. But this is not practical, because, among other things, a variety of focal lengths of projecting lenses are required for different projection distances, or "throw" as the operator usually terms it. The preferable arrangement is, therefore, to put the shutter in front of the lens, and then to have the rays of light cross at that point.

The principal reason for having the shutter at the narrowest part of the projected light-beam is that the obscuring blade may be as narrow as possible, so that when the other two blades, the flicker blades, are added they may each approximate the width of the obscuring blade and yet give a fifty-fifty ratio of light to darkness, which is the ideal arrangement for a flickerless picture today.

To readily determine where the light beam is narrowest is not alwasy easy, for the light cone is not readily discernible. If, however, a card is passed vertically through the light just in front of the lens, a shadow will cross the screen, say, from top to bottom; with the card farther out the shadow will cross from bottom to top; but at a median position the passing of the card causes a shadow to cover the whole screen at once. That is the proper location for the shutter. One should remember, however, that a shutter that is just right, that is, most efficient, at this point will show halation or streamers, both above and below the letters of a title, if the arc is moved very much either toward or away from the condensers.

There are other factors also which have a bearing on the location of the various elements of the projection system. For example, a longer projection for the same size picture requires a projection lens of longer back focus. This again requires a longer cone of light from the converging lens. This lens must, therefore, be changed for one having less curvature. But when this is done the light spot on the aperture is too large, and the lamp house must be moved back. This draws the apex of the light cone back within the projecting lens barrel, so that another change is required. By repeated trials one would

probably find the proper lens and best lamp-house position, but the easier plan is to advance the arc a little when an approximately correct lens and lamp-house position is found, and this is usually done.

When the lamp-house is moved back for the long "throw" it is not unusual to change the arc lens to a 7½ lens, making the combination two 7½ lenses. The resultant light loss is considerable, however, 50 per cent, perhaps. This loss of light has given rise to an erroneous idea that the longer throw requires a correspondingly greater amount of current for a given size screen. Another plan is to let the 6½ arc lens alone, and substitute an 8½ lens for the 7½ converging lens. This will give the same amount of light on the same screen at the longer distance, without increasing the current consumption. A 6½-inch and 8½-inch lens combination has practically the same equivalent focus as two 7½" lenses, though the reciprocals are not exactly identical in both cases. However, the distortion of poor lenses sometimes prevent getting an even, white-lighted screen.

This brings us very naturally to the consideration of a better lens arrangement for the lens next the arc, for, if this can be made a fixed factor, then the matter of adjustment for different lengths of throw is simplified.

Taking up the consideration of the arc and the theoretically best adjacent lens-surface it is at once apparent that if a curved surface could be employed, the same safe distance might be maintained between the arc and the lens at its center, while the outer edge of the lens, by reason of its enveloping curvature, would gather very much more light. But to make a single lens of this conformation having the same 6½-inch focal length as the plano-convex usually employed gives the opposite or convex surface of the lens a disastrous curvature. A better plan is, not to attempt the total light refraction with the one lens, but set another close thereto having such a curvature that the sum of the two will give the focus desired. A lens of — 1½ and + 6½ (dioptric measurement), say 8" focus, in combination with a 10-inch, either bi-convex or a plano-convex, is about correct for a three-inch arc location and is an ideal arrangement, but unfortunately, it is only ideal. A meniscus of six-inch focus would have to be about a + 7 which, obviously, is not practical. The use of a — 1½ and + 5½ lens, about 10" focus, in combination with either a bi-convex or plano-convex lens of 10-inch focus, is good, being approximately the equivalent of a 5" lens. This combination used with a 7½, 8 or 8½-inch plano-convex, seems to make a very satisfactory three-lens meniscus set.

There is still another factor to be taken into consideration—namely, the liability of condenser breakage. But, as has been explained, if the arc can be kept close to the lens very much less current is required for the same screen illumination. And right here a Kelvin law helps us very materially, i. e., "the light of an arc lamp increases directly as the increase in current, while the heat increases as the square." Obviously, therefore, if we can employ such an arrangement as will require but half as much current as another we get but one-fourth as much heat.

But at best the heat is such that the condenser gets very hot though the heat of itself alone does not crack lenses. In actual practice I have found that if the arc lens is held in a non-conductive ring it will never break no matter how hot it gets. Lenses crack because of unequal stress in the glass, and this comes about because something has carried away heat from a limited area and not from the whole mass evenly. Thus, if one should touch a very hot lens with a piece of metal, say, a screw driver, the lens will crack, because the metal being a better conductor of heat than the glass robs the glass of its heat at the point of contact and the equilibrium of stress is disturbed and the glass cracks. I have had the glass crack across between my thumb and finger when I attempted to pick up a hot lens by its edge (without knowing before that it was hot). If the lens is heated evenly and remains so, that is, is not robbed of any part of its heat by a conducting or convecting medium it will never break. A complete understanding of this phenomena and its proper recognition by the operator, would enable him to get a much more brilliant screen picture with much less current consumption.

It is exactly the same with many other improvements which might be attempted if we had graduate engineer operators to handle our machines. So the best we can do is to make a compromise machine and wait until the public grows up to our ideals. In this category is an adjustible shutter; and the three-lens condenser system I've just been talking about; and, to come closer home, a multiple-negative carbon arc with its single unshadowed crater in the exact axis of the optical system, an ideal arrangement which we had to give up because we couldn't take the time to teach each operator where such a lamp was installed, if, indeed, he were teachable.

Much of what is here explained could be calculated with exactness and applied by rule if the source of light were an infinitely small point, and condensers were as carefully ground and annealed as projection lenses, which, however, isn't the case. Also the condensers and light source area have a definite bearing on the sharpness and brilliance of the screen picture aside from the question of illumination. The optical system of motion picture machines is a makeshift, and I hope that some of us will undertake a systematic investigation of it looking to a more definite knowledge and resultant improvement.

In conducting experiment with motion picture machines it is desirable, on occasions, to take the heat out of the light so that the light may shine on the film continuously for an indefinite time without igniting or puckering the film. The usual plan is a tank of water, located between the condensers and the picture aperture, through which the light must pass. This is a help, perhaps, but not wholly effective. Alum is sometimes added to the water, but, so far as my experiments go, adds nothing to its heat absorbing property.

After repeated trials and finding that the water cell did not furnish the required protection, I set about to find out what would, and developed some surprises. Our first surprise was the discovery that ice water was less effective than warm water. Next I found that a

plurality of thin glass plates, spaced apart, served the purpose admirably. The only trouble encountered was the breaking of the plates through which the light first passed. This, because the plates were heated in the region of the light spot faster than the glass could conduct it to the parts of the plate lying outside the path of the light.

To overcome this difficulty, a water cell was made into which glass plates were put, the water serving the purpose of equalizing the heat over the whole surface of each plate. No more breakage was then encountered. In order to dispell any doubt in your mind about the true reason for the results, I might add that after the cell was filled with water, but before the spaced glass plates were put in, the film ignited in from 32 to 35 seconds, but that after eight or ten plates were put in, the film was not ignited, or even puckered, after repeated tests of 25 to 30 minutes duration. This device cuts off some light—I have not yet had time to measure the loss—but a 50 per cent loss is permissible and still have as much screen illumination as results from the running of the machine without it but with the usual 50-50 shutter.

In this connection it may not be amiss to caution any of you who may wish to construct such a cell, that the cell must be not less than about three times the width of the beam of light. I am not yet ready to say just why a narrow cell is not as good as a wide one in preventing the ignition of the film, and so will reserve a positive statement until from repeated experiments I can be certain of it.

Another thing which is interesting is that the same number of plates in surface contact with each other will not prevent ignition. A mica cell with spaced sheets is also effective, but the color of the mica and the flimsy, thin sheets are objectionable.

Another observed phenomena which gives further evidence of the complexity of the projected light is that:—

There is a point between the condensers and the aperture plate at which a pencil, screw driver or other slender object held in the cone of light does not cast a shadow on the screen.

This seems incredible, but comes about probably because the heat rays, the light rays, and the color rays, which had, therefore, been more or less separated, so criss-cross and mix-up at this point that there are not enough directed rays to carry a defined image to the screen.

Further investigation of the light in this region is being made and will perhaps be presented in another paper following this primer presentation of the subject of condensers in motion picture projecting machines.

In concluding, let me encourage you to original research, for the field is full of opportunity for profitable investigation. Stop a moment and think of it; no material change has been made in the mechanism, and no change whatever in the principle involved in projecting machines since the first projecting machine was deposited in the U. S. National Museum twenty odd years ago. It had the

same arc lamp used today, the same two condenser lenses, the same aperture with tension plate, the same upper and lower sprockets, the same left-handed construction, and the same noise of an intermittently-moved film. Here is abundant opportunity for original research work and improvement.

Nor have facts relating to lamp-house setting, lamp location, condensers, or other similar factors, been tabulated,—not even the averages of the thousands of machines in use today. I think it should be done.

A condenser lens which I believe would be worth while to experiment with is the corrugated principle employed in light-house lenses. I hope that at our next meeting some one will be ready to read us a paper on lenses of this character.

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

MEETING of APRIL 6-7, 1917

ATLANTIC CITY

NUMBER THREE

TWENTY-FIVE CENTS

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OCTOBER, 1916

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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers is a marked distinction. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts; and an Associate Member is one who, though not eligible to membership in the active class, is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least two members in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee (for both Active and Associate Members) shall be twenty-five dollars ($25.00). The annual dues for Active Members shall be ten dollars ($10.00), payable in advance on July 1st of each year. The annual dues for Associate Members shall be five dollars ($5.00), payable in advance on July 1st of each year. That is, the total fee for the first year, which includes the entrance fees and first annual dues, is $35.00 for active members; and similarly $30.00 for associate members.

PRESIDENT'S ADDRESS

GENTLEMEN:

When in October this meeting was set for Atlantic City, I wondered who would come. I am gratified, therefore, to see so many of you here, for you represent the workers, those who can be depended upon to accomplish things.

For we have not come here two days in advance just to secure a grandstand seat for the Easter Sunday parade. We came to further our standardization in the motion picture industry, a standardization which we will continue from year to year, as our industry grows and takes on the welcome stability of approaching harvest time.

I think we may with profit and prophecy compare our industry to the sun flower, which from a tiny seed shoots up in the spring a tender green sprout which the browsing beast crops if left unwatched. But safely past this period of growth it begins to form a woody stalk able to stand alone against the autumn winds and hold aloft its golden crown.

Our industry is not quite past the stage where covetous eyes have ceased to watch for an opportunity to "bite us," but we are rapidly approaching that time when we will be able to resist stress by reason of the solidity of mature growth.

This is also the exact situation with regard to our Society. We will now quickly come to the maturing season, or we will die an ignominious death.

Solidity, the ability to stand alone, comes not so much in numbers as in individual strength—confidence in one's self. Not one single enduring movement was ever begun with numbers. Numbers alone count for very little. A mob easily forms, but just as quickly melts away. Permanency comes from individual confidence in the ultimate success of a fixed purpose.

Now the prime purpose of the organization of this Society was to standardize our industry. The way to standardize is to standardize. We will not accomplish it all this session, but without leaving this room there is plenty that can be done to wonderfully help the industry.

There are many looking to us to establish these standards. Most of those who have written me say they do not care so much what the standards are, being ready to accept any standard so far as they can be assured that it is the consensus of opinion of the engineers of this Society. In fact, they are anxious to do so as they have no other authoritative body to consult.

So let's get busy now and tabulate the majority opinion of our members on the several subjects to come up for consideration at this session.

Gentlemen, the meeting is yours.

C. FRANCIS JENKINS.

MOTION PICTURE CAMERAS

CARL LOUIS GREGORY, F. R. P. S.

The rapid growth of the motion picture industry has made it a difficult problem for manufacturers of motion picture apparatus to keep pace with the growing demands of the industry. The manufacturing problems have paralleled in many respects those of the automobile industry, but have by no means kept pace with them. It was only with the standardization of parts, and with the adoption of a standard method of measurements and specifications, that the automobile industry was able to reach the development that it has today. The American Society of Automobile Engineers was probably the largest factor in bringing about the standards in use in the automobile industry. It has, every year since its formation, helped in the elimination of freak designs and in rendering obsolete the unnecessary duplication of parts in odd sizes. The old idea of a manufacturer who would compel a customer to replace every part of a car from parts manufactured in that particular factory by making as many of the parts as possible of a different size from that of any other manufacturer is one which has never met with the approval of the consumer. If a car owner wished to use a different spark plug or piston ring than that supplied by the manufacturer of his car it didn't improve his state of mind to find that no other make of spark plug or piston ring would fit. No manufacturer ever benefited by this selfish attitude, for as soon as he had turned out enough of his odd sizes to make a market every other accessories maker turned to and made an odd size to fit it. This duplication of parts entailed more machinery, higher costs and, consequently, bigger prices for the consumer to pay.

Although it would seem at first inspection that the fact that the size of the film is practically an international standard and would, therefore, militate against an undue multiplication of parts in the film business, still we find on closer inspection that affairs are as bad or worse than they were at one time in the manufacture of gasoline vehicles. It is to be hoped that the Society of Motion Picture Engineers may do the same service for the motion picture industry that the American Society of Automobile Engineers is doing for the automobile industry.

One of the first things to put in order out of the chaos of filmdom is a comprehensive and comprehensible list of specifications by which a camera may be described. No manufacturer of automobiles would think of issuing a catalogue describing his car without including a full and detailed list of specifications. Yet none of the camera manufacturers have seemed to think this necessary in the catalogues describing their cameras. They often elaborate to great extent on some one feature or another, but slide gracefully out

of describing some of the essentials which they have left out of the catalogue, and generally left out of the camera also.

The camera is the keystone in the arch of picturedom. Without the camera the whole structure must fall to the ground. It is therefore of the utmost importance that the first attention of this august body be directed to the vital centre upon which every other section of the industry depends.

The average camera of the industry today is a marvel of compromise. It is expected to take the film of any maker, of any thickness and any degree of pliability, with perforations of any shape and almost any number per foot and produce a rock-steady picture. I say it is a marvel for it generally accepts all these handicaps and turns out pictures which look surprisingly good upon the screen.

It must accept all of the imperfections which a lack of standards subjects it to and turn out a picture degraded with an average of these imperfections.

Its sprocket teeth cannot fit the perforations for they must be made small enough to enter the smallest perforation that it may encounter. It must rely for registrations upon pressure plates with spring tension-pilot pins or guides being of little use unless a standard size of film and perforation be arbitrarily adopted for that particular camera. Thanks to the individual efforts of one or two of the members of this society, much excellent work in this line has been accomplished, but unless standards are universally adopted and used the standards of one clique are sure to clash somewhere with those of another clique and the war goes merrily on to the detriment of the industry as a whole.

It is high time that the essential parts and features of cameras have a universally recognized standard to which they should conform.

The first and most important standard to be determined is the frame line in its relation to the perforations. No two cameras can be used in the same production at the present time without having their frame lines adjusted to one another. The claws or fingers which engage the film for drawing down the succeeding frames are placed, in most cameras, at some distance below the frame opening and although two cameras with claws at different distances between their claw movement be adjusted according to one standard for their frame line, the use of a different standard of perforation, although the new standard be used in both cameras, will cause the frame lines to differ.

The studios of today who are turning out the best grade of work have adopted a standard for their plant and, at great expense, have made all of their cameras, perforators, printers, etc., conform to an arbitrary measure for their own protection. The companies who have recognized this great economic factor in production are unhappily still in the minority. It is not to be wondered at that in the absence of recognized standards that many makers have either never given the subject proper attention or felt equal to backing the various opinions of the others and trying to draw them into line.

An instance will illustrate the point which I am trying to bring out. One of the largest distributing combinations in the country shortly after their organization decided to run a trailer with their trade mark on all of their reels. They made an appropriation of stupendous proportions to bring this trade mark before the public by a national advertising campaign in magazines, newspapers and billboard space. I was assigned the task of making the negative for the trailer, pieces of which were sent to each company releasing through this organization. I made the negative with the frame line conforming to the standard of the principal member. It took nearly four months to bring this trailer into use among the different releasing companies, during which time it was necessary to remake an exact duplicate for each and every releasing company with a different frame line, and one company was even so sadly mixed that it required a frame line change to correspond to each camera that it owned, they were not able to put two camera men on the same job as their frame lines did not correspond.

A large number of camera men at the present time own their own outfits. This measure was adopted by them in the beginning as a measure of self-protection against the junk-boxes with which the manufacturers expected them to work.

As soon as the manufacturers found that the camera men would buy their own cameras many of them ceased providing cameras and depended altogether upon the heterogeneous collection of outfits that their camera men provided.

This situation is absurd—can you imagine a serious manufacturer of automobiles or machinery who would expect a workman to come into his factory with an arbitrary set of limit gauges and expect to assemble a product made by this workman with the product of other workmen when their measurement standards had never been compared?

That, gentlemen, is exactly the situation in a number of studios today where they are spending into the millions of dollars each year for the production of feature pictures de luxe.

You are all well aware that I might go on with an almost interminable list of evils that are crying out for extermination at your hands but I would be taking up time which would be better spent by you in devising remedies that are so sorely needed.

Fellow members, upon your decisions at this and coming meetings rest the savings of untold amounts of unnecessary waste in time, money and material.

REPORT OF COMMITTEE ON ELECTRICAL DEVICES

MR. HARVEY M. WIBLE, Chairman
MR. MAX MAYER
MR. W. G. KUNZMANN
MR. H. A. CAMPE

INTRODUCTION

1. Advantages and disadvantages of alternating current; How objections may be overcome.
   (a) Advantages.
   (b) Disadvantages.
2. Advantages and disadvantages of direct current; How objections may be overcome.
   (a) Advantages.
   (b) Disadvantages.
3. Various methods of changing from alternating to direct current when alternating current is available and direct current is desired.
   (a) Mercury Arc Rectifiers.
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4. Various apparatus for obtaining proper arc voltage when alternating current is to be used.
   (a) Choke Coil or Reactance.
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5. Determination of proper arc voltage for both direct current and alternating current at various currents.
6. Relation to alternating current of frequency flicker and its synchronization with the shutter.
7. Nature, size and structure of carbons required for both alternating and direct currents for various currents.
8. Proper angle of carbons for alternating current and direct current.
9. Maximum density of current at carbon points in order to obtain maximum efficiency.

In the early days of the motion picture industry, the source of light was, in many instances, of the well known calcium type. Artificial gas, such as acetylene was also used, but as the public became interested in this new form of entertainment and education, the demand for a better form of illuminant necessitated discarding these sources of light. This was due to the increased size of the picture theatres and the demand for larger and better illuminated or more distinct pictures. It was for these reasons, primarily, that the electric arc was adopted for motion picture work.

The electric arc is particularly well adapted to this service as it is one of the most intensely brilliant artificial illuminants known to science. The major portion of the light produced, however, is not obtained directly from the arc, but from the incandescent tips of the carbon electrodes. The brilliant illumination of the film is secured by the condenser lenses which collect a portion of the light produced and converge it through the aperture plate, the illuminated area being generally known as the "spot." It is obvious, therefore, that if the spot is to be uniformly bright over its entire area the source of light must be concentrated in a fixed and as small a point as possible.

1. (a) The earliest current supply used for an electric arc for a light source for projection work was alternating, due to the fact that alternating current is more widely distributed and therefore, more readily available, and also because control apparatus for alternating current was simpler, more easily designed and less expensive. It is practically impossible to find direct current mains everywhere, except in the centers of some of the large cities, while alternating current is available at practically all places where there is a sufficient number of people to warrant the establishment of motion picture houses. The apparatus for the control of alternating current for an alternating current arc is simple, comparatively inexpensive, and on the market in a variety of forms readily available for practically any current throughout the range of application. The advantage of alternating current from a carbon standpoint lies only in the efficiency of the supply to the arc. By means of a transformer, reactance, etc., the line voltage can be very readily reduced to any value required by the arc with very little loss of power.

1. (b) That the arc produced by alternating current is not so satisfactory as the arc produced by direct current is quite generally recognized. This fact is due to a number of physical characteristics of the alternating current arc. (1) Both electrodes are heated almost uniformly, producing practically equal illumination. However, only the incandescent tip of one carbon can be located at the proper focal point for the condenser lenses. (2)The average temperature of the crater is comparatively low on account of the rapid transfer of this crater from one carbon end to the other. (3) If an improper revolving shutter is employed or if a satisfactory shutter is operated at other than correct speed, the pictures will have an undesirable flicker, due to the fact that the value of the alternating current is zero twice

each cycle of 120 times for a 60 cycle circuit. (4) The alternating current arc has a greater tendency to travel around the ends of the electrodes, which constantly shifts the incandescent area of the carbon tips, thus producing "ghosts" on the screen. (5) The light produced by alternating current has a preponderance of the violet end of the light spectrum, which is not so desirable as the yellow, from an optical point of view. (6) The cost of power for the alternating current arc is high, because the current required to produce a given illumination is about three times greater than the direct current required. From a carbon point, the disadvantage is chiefly in operation. The very highest grade, and therefore costly, carbons are required. The very short arc required for satisfactory operation means constant attention on the part of the operator. Further, the high currents necessary to get the degree of illumination now considered desirable, renders such an arc very noisy, which in itself is a hardship on the operator.

2. (a) The advantages of the direct current arc can be briefly stated as being converses of the disadvantages which have been cited for the alternating current arc. Careful experiments have demonstrated that the light resulting from a direct current arc is produced by the crater on the positive carbon, by the incandescent tip of the negative carbon, and by the arc stream proper, in the proportions of 85 per cent., 10 per cent. and 5 per cent., respectively. The crater is of comparatively small area and can therefore be located at the proper focal point of the condenser lenses. This explains the fundamental advantages of the direct current arc. The ease of operation, requiring little attention from the operator and the inherent stability and good operation of the direct current arc over wide range of arc voltages, makes this form of current ideal. Very high arc wattages can be made use of on direct current to obtain the illumination essential for very large pictures, but which would hardly be feasible to attempt with alternating current, so that in the field of projection in the large picture houses, direct current is supreme.

2. (b) The disadvantage of using direct current is primarily in the cost of converting appliances to change from alternating current to direct current, or if operating directly from 110 volts direct current, the entire line voltage enters into the cost consideration, since whatever energy is not used in the arc must be dissipated in resistance.

3. (a) If an alternating current supply system only is available and direct current is desired for the projecting machines, it is necessary to install equipment which will rectify or convert the alternating current to direct current. There are numerous types of equipment available for this survice, such as Mercury Arc Rectifier, Motor Generator Sets (of which there are two classes, namely, constant potential and constant current), Rotary Converters and Mechanical Rectifiers. When any one of the various types of converting equipments is used, with the exception of the Mercury Arc Rectifier, it is advisable to provide for "break down" service, so

that if the auxiliary equipment is disabled, the projectors may be operated temporarily with alternating current.

4. When alternating current only is available, and is to be used, the apparatus for obtaining the proper arc voltage may consist of a choke coil, reactance, transformer or rheostat. The transformers ordinarily used are of the single winding or auto type designed with sufficient reactance to stabilize the arc. A standard double winding transformer having suitable voltage characteristics could be used, providing a suitable reactance coil is connected in series with the arc. Rheostats should not be considered on account of their extremely low efficiency.

5. On Alternating Current a very short arc must be maintained; we cannot deviate from this operating condition. The arc voltage is, therefore, settled for the operator and usually is between 33 and 39 arc volts; that is, at a very short arc just after feeding, the voltage may be 33 and as the arc length increased with the burning of the carbon, the arc voltage will increase to a value of about 39 volts, if the arc is permitted to get any longer we find an immediate irregularity and unsteadiness in the arc. It will be found in practice that an Alternating Current will require feeding every 75 seconds. On Direct Current we have an inherently steady arc; that is, inherently steady as compared with an Alternating Current. The range of arc length and arc voltage can be made whatever the operator desires within certain limits, but there is one fact to be borne in mind, and that is, that for each given current value there is a definite arc length and arc voltage at which we have the most efficient operation. This can be determined in the following manner: Set the Carbons for a constant current, then shorten the arc length gradually and you will finally produce an unstable, noisy arc. Just previous to that point is the minimum limiting arc length for that given current and given carbons. Likewise, take a given arc length and increase the current until a noisy and unstable arc forms, then decrease the current a trifle and you will have the condition of maximum efficiency for that arc length. Because of the fact that a given arc length can only accommodate a certain maximum amount of current, it can readily be seen that we must increase the arc length each time we increase the current. Arc length is of course synonymous with arc voltage, so wherever we have mentioned increasing arc length we can say increasing arc voltage. So making this change in nomenclature we can make the statement that increasing current values in an arc requires an increased arc length and voltage. In actual practice it is found that there is some variation in the arc voltage for a given current with the make of the carbons and the combinations used, so that the voltages which we have listed are averages which are built up on the principles given above.

For direct current combinations using the ordinary positive carbons as indicated in the table and matching them up with plain negatives "Group A" we have a table of voltages as indicated in the following table marked "Group A" Negative Voltages:

Amps.	Group A Negatives Arc Voltage	Group B Negatives Voltage
30	52	52
40	55	54
50	58	56
60	61	58
70	64	60
80	67	62
90	68	64
100	69	66

In the above table, the table of voltages given for the combinations in which the positives are matched up with small negatives of "Group B" it will be noticed that these voltages are somewhat less. It has been found in actual practice that a well shaped crater can be obtained at these lower voltages with negative carbons of diameters which are one-half that of the positive. The usual size negative is approximately two-thirds the diameter of the positive. These special small negatives are metal clad in order to give them carrying capacity and life since they are operated at current densities far beyond their possibilities were they not metal clad.

6. The electric arc when operating on Alternating Current is known to possess the peculiarity of varying in intensity to a marked degree with the peak and zero points of the alternations; being clearly visible to the eye on frequencies under 40 Cycles.

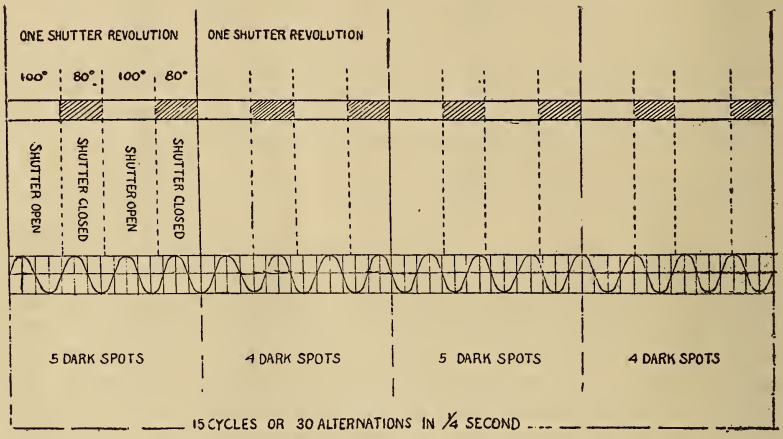
At commercial frequencies higher than 40 Cycles, this may be visibly demonstrated by moving under the arc a light colored pencil, or other object, against a dark background. When moved rapidly under direct sunlight or direct current arc, the pencil would naturally appear blurred, owing to the rapid change of position. Under the alternating current arc, the rapidly moving pencil would seem to be a number of pencils, each one clearly visible, with dark intermediate spaces. This is precisely the same effect as is obtained by moving the pencil in the light beam of a projector with the shutter revolving.

In reality, we are therefore dealing with two intermittent periods in the light source, when operating a film projector with an alternating current arc; namely, the light interruption of the shutter and the rise and fall of the light intensity of the arc. The former depends for its frequency upon the speed of rotation of the shutter and the number of wings therein; while the latter depends upon the frequency of the current.

In determining the relation between current frequency and shutter movement, we might for example imagine a shutter with three 60-degree openings and revolving at 40 revolutions per second.

This would give us 120 dark spots per second. An arc lamp on 60 cycle current would also have 120 dark spots per second. It is therefore evident that under these conditions, if the shutter opening occurred at the same instant at the zero point of the cycle, practically

no light would be obtainable on the screen; as the shutter wings would block out the light each time it occurred.



If now the shutter be moved 60 degrees on its shaft, the maximum light would be obtained, as then the shutter openings would register with the peaks of the current alternations. These conditions, of course, would prevail only if the shutter and current were perfectly synchronized. If the speed of the shutter were reduced to 20 revolutions per second, 4 peaks at each opening.

While the 60 cycle current prevails in practice the aforementioned speed and shutter openings do not; consequently, at the normal shutter speed of 16 revolutions per second, the shutter openings would be out of step with the current frequency, with the result that some of the shutter openings would receive one, some two and some three impulses of light, causing a visible variation of light on the screen.

Since each projected image is illuminated for a time period equal to the sum of all the shutter openings during one revolution, the light impinged on each image would be the same if the light source were constant. With the alternating current arc, the light would vary with the number of peaks to each respective image, the variation and resulting flicker depending upon actual difference in frequency of shutter flicker, or in other words, depending on how much they are out of step.

The following diagrams show these variations under the normal conditions of a projection speed of 16 images per second, with a 60 cycle arc, and using a commercial shutter of two 80-degree wings with two 100-degree openings.

It is obvious from the above that a current flicker can be avoided in alternating arc projection, only by occasional accidental synchronizing for short periods of time, or by a carefully planned synchronization, together with special shutter design.

It is evident that current flicker is an inherent objection to alternating current arc projection. There are other faults better known, such as the bluish color of the light, the poor concentration of light at the light source focus of condensor, and the noisy hum of the arc.

Without entering into details of these other objections, which are apart from the subject matter of this paper, the mention of them seems permissible, as it completes the evidence against alternating current projection, and proves its use poor practice.

Since the direct current arc possesses none of these objections and since a large variety of thoroughly satisfactory and practical apparatus is on the market for converting alternating current to direct current, there seems to be no excuse for faulty projection, resulting from the use of alternating current.

For alternating current, cored carbons in both upper and lower are always used and these are the same size. This is essential, of course, since the rate of consumption is practically the same for both the upper and lower carbon. On direct current some operators use cored carbons, both upper and lower, and also use the same size carbon for the positive as well as the negative.

While it is sometimes desirable to use cored carbons, both positive and negative, it is the wrong principle to use the same size—the negative carbon should always be smaller than the positive.

For all around service the most advisable ratios will be such that the cross section of the positive carbon would be twice that of the negative carbon, but in actual practice we find that a negative carbon would not have the carrying capacity for the current required for the positive, if the latter were operated at maximum current density. Therefore, the following combinations are a compromise which have been standardized for various current densities. These are as follows:

MAXIMUM CURRENT.

Size	Alternating Current	Direct Current	Plain Negatives Direct Current	Metal Coated Neg. Dir. Cur.
1″	100	85-100	3/4 Cored or sol.	3/8 sol. spec. coated
7/8″	90	65-85	3/4 " " "	3/8 " reg. "
3/4″	75	50-65	5/8 " " "	11/32 " " "
5/8″	60	50	1/2 " " "	5/16 " " "
9/16″	50	40		
1/2″	40	35		
7/16″	25	25		
3/8″	15	15		
5/16″	10	10		
7 m m	8	8		
6 m m	6	6		

In the table of direct current capacities, from the 5/8″ size up, the next smallest sized solid carbon is used as the negative.

Cored negative carbons give steadiness at the cost of the candle power of the arc. Under certain conditions it is possible to operate carbons at somewhat higher current densities than here given and still obtain satisfactory service. It is, however, essential, in order to

operate at these higher current densities, that special small diameter metal coated negative carbons be used, the reason being as already mentioned that such combinations can be operated at high current densities, with short and steady arcs free from noise, whereas for the same current density and the use of ordinary negatives, the arcs would be unsteady.

8. Since the light from the direct current arc is emitted from the crater of the positive carbon, it is desirable that the carbon be tilted at such an angle as to point the crater directly at the lens, and still prevent the lower carbon from cutting off the light. An angle of about 25 degrees has become standard for this service. With an alternating current arc the light is given by both carbons, which means that it is desirable to use the carbons more nearly vertical. A slight angle is, however, necessary in order to make draft conditions correct.

9. With Alternating current the carrying capacity is limited by the ability of the carbon to carry the current, whereas on direct current, it is limited by the ability of the crater to stand up under high current densities; that is, the 5/8″ carbon can carry 60 amperes alternating current without undue heating, but on direct current 50 amperes would be the limit, since a higher current value would tend to break down the crater formation with subsequent unsteady operation.

MOTION PICTURE NOMENCLATURE

ADOPTED IN COMMITTEE OF
THE WHOLE SOCIETY

cine—A prefix used in description of the motion picture art or apparatus.

condensers—In an optical projection mechanism, the lens combination which gathers the diverging rays of the luminant and converges them into the objective.

douser—The manually operated door in the projecting machine which intercepts the light before it reaches the film.

frame (noun)—A single picture of the series of a motion picture film.

frame (verb)—The adjustment of the relative position between the aperture and the pictures on the film to bring them into register with each other.

intermittent sprocket—The sprocket (in motion picture apparatus) which engages the film to give it intermittent movement at the light aperture.

lantern picture—A still picture projected on a screen by means of an optical lantern.

lantern slide—The transparent picture from which a lantern picture is projected.

magazine valve—The film opening in the magazine of a motion picture projector.

motion picture—The synthesis of a series of related picture elements, usually of an object in motion.

motion picture film—The ribbon upon which the series of pictures are recorded.

motion picture projector—An optical lantern equipped with mechanisms for suitably moving motion picture film across the projected light.

negative stock—Light sensitive film intended for motion picture camera use.

negative—The developed film, after being exposed in a camera.

objective—The image-forming member of the optical system in picture apparatus.

positive stock—The light, sensitive film intended to be printed upon through a negative.

positive—The developed film, after being printed through a negative.

print—Same as **"positive."**

projecting lens—The lens (in an optical machine) which images the picture on the screen.

reel—The flanged spool upon which film is wound for use in projecting machines.

reel—An arbitrary unit of measure for film—approximately a thousand feet of length.

rewind—The process of reversing the winding of a film, usually so that the end to be first projected shall lie on the outside of the roll.

rewinder—The mechanism by which rewinding is accomplished.

safety shutter (also known as the fire-shutter)—The automatically operated door (in a projecting machine) which intercepts the light when the machine runs below normal speed.

screen—The surface upon which a picture is optically projected.

shutter—The obscuring device, usually a segmental revolving disc, employed to intercept the light during the movement of the film in motion picture apparatus.

shutter—working blade (also known as the cutting blade or obscuring blade)—That segment which intercepts the light during the movement of the film at the picture aperture.

shutter—intercepting blade (also known as the flicker blade)—That segment which intercepts the light one or more times during the rest or projection period of the film.

sprocket—The revolvable toothed member (in motion picture mechanisms) which engages the perforations in the film.

take-up (verb)—The process of winding the film (in a motion picture machine) after it passes the picture aperture.

take-up (noun)—The mechanism which receives and winds the film (in a motion picture machine) after it passes the picture aperture.

throw—The distance to the screen from the objective of a lantern or a motion picture projecting machine.

still—A picture printed from a single negative.

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

MEETING of JULY 16-17, 1917

CHICAGO

NUMBER FOUR

TWENTY-FIVE CENTS

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FROM THE

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

MEETING of JULY 16-17, 1917

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OCTOBER, 1916

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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers stands for unselfish service to the Industry. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts; and an Associate Member is one who, though not eligible to membership in the active class. is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least two members in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee (for both Active and Associate Members) shall be twenty-five dollars ($25.00). The annual dues for Active Members shall be ten dollars ($10.00), payable in advance on July 1st of each year. The annual dues for Associate Members shall be five dollars ($5.00), payable in advance on July 1st of each year. That is, the total fee for the first year, which includes the entrance fees and first annual dues, is $35.00 for active members; and similarly $30.00 for associate members.

PRESIDENT'S ADDRESS

Chicago, July 16, 17, 1917.

The Society of Motion Picture Engineers is rapidly losing its aspect as a collection of individuals and instead is commanding a national recognition as a solidified body. I may have taken a personal pride in complimentary references to my connection with the initial establishment of this Society, but my own individuality is rapidly being lost in the office of President, as the Society becomes more and more useful. And this is as it should be, and confirms what has been said before, that this Society's recognition and the regard in which it is held by the industry will be directly in proportion to the unselfish service its individual members are willing to give collectively.

And this has its own reward, too, for there is a pleasure in unselfish service, which many of you know, a lasting satisfaction which no pecuniary reward can give. It is no particular credit to one to do a thing for a salary, anyone can do that; the most enjoyment in life comes from doing for the love of doing.

In the same spirit let us now establish as many standards as the data before us warrants and prepare to continue the work at each succeeding meeting. Certainly there's plenty that can be done when standardization is accomplished. Take projectors for an example:

It is curious anomaly that in the motion picture projecting machine business the usual rule of supply and demand does not hold good. One may buy anything else, a watch, an automobile a house, paying as much or as little as one chooses, getting increased value with increased cost, but for a motion picture projector, one pays about the same price for all makes, a remarkable situation, surely. Suppose we all had to pay $1000 for automobiles—no more, no less.

There is not today a picture equipment comparable with the magnificence of a great many of the theatres built and many more projected. No matter how much the builder of a fine theatre may desire a correspondingly fine equipment, he can't get it, it doesn't exist. He may pay as much or as little as he likes for music, lighting and other accessories, but when it comes to the picture machine, that which produces the thing he sells

to the public, he is limited to a choice in name, mostly, for the three or four machines available all sell for about the same price.

About twenty-five years ago, by accident, or shall I say, the irony of fate, it fell to my lot to make and exhibit the first of the present type longitudinal projecting machines, a type which has become universal the world over. This early model has been in the United States National Museum for twenty-two years, and may still be seen on exhibit in the Graphic Arts department.

Now, it certainly seems to me that this is long enough to wait for a marked advance, and that the problem is squarely up to the motion picture engineers, including myself with perhaps added responsibility by reason of this early work, to give the fine theatres a correspondingly fine projecting machine. And in order that those of you who may be interested in designing such, may have the benefit of the data I and my engineer staff have developed by costly experiment, I shall be glad to show you, as individuals, what we have learned in order that your work may receive the impetus of enthusiasm which comes from a newly opened door in any art; as, for example, when the newly discovered formula was made to the engineers of that time that 3.1416 times the diameter would always give the circumference of a circle.

Similarly, this picture information is yours, but to save myself the criticism of using my office for selfish publicity, I suggest that this be not published in the "Transactions" of this meeting.

Surely, it is time for a duplex, electrically-driven, self-controlled, automatic picture projector, a fine, high priced machine for fine theatres, and I earnestly urge you projector engineers to get busy along this line.

It may be remembered by some of you that the first steam engine employed a boy operator to manipulate the crank which shifted the entering steam from one end to the other of the cylinder of the engine. But this hand operation only continued for a few weeks before the boy ingeniously fixed it so that the engine automatically shifted the slide valve. This boy's cleverness made possible the development of the railway locomotive, perhaps man's most effective civilizing agent.

It is not particularly creditable to we engineers that we are now only just beginning to think of an advance over the crank turning stage in the motion picture business.

There is unlimited opportunity for advance, both inside and outside the industry as an entertainment. If there had been any question before as to the need for a standardizing body, such as the Society of Motion Picture Engineers, it vanished when the Federal Government, unable to find any authoritative standard, appointed me as an individual, to write the specifications for a war service motion picture camera for the Army and Navy in order that official pictures made of this great war would be alike in quality and frame line at least. Specifications were prepared with such assistance from our camera members as could be secured in the forty-eight hours allowed, the credit therefore being given our Society for the added prestige, and to publish the fact that there is now an authoritative body to whom one may apply for information of this very kind.

Our standards, definitions of trade terms, and uniform methods will soon come to be consulted in writing specifications, in trade contracts, in court contests, etc., and I think we should not only be a bit more self-respecting when we remember this, but that we should also feel our responsibility to set standards with due regard for the rights of all. This will tend to give us a more creditable standing everywhere. It is a bit embarrassing to me today to notice the suspicion in which I am held by strangers the moment they find I am talking motion picture business.

Fair treatment of the other fellow is a great business asset of which the motion picture industry hasn't yet taken full advantage. It is a builder of confidence in any industry which returns its cost a hundred fold in dollars and cents. If this spirit permeates the printed Transactions of this Society, as I believe is our intent, it will do our Industry untold good as the copies get wider and wider distribution. When this confidence in our integrity of purpose and accomplishments is entertained by the big men in our industry, they will buy quantities of these printed transactions for distribution among their employees in order that they may be guided by the standards, the working data, and technical information contained therein, and the Industry at large will greatly benefit thereby.

Gentlemen, the time is near when we may take creditable pride in the work we have done, are doing, and plan to do.

Membership in the Society of Motion Picture Engineers, is a signal distinction.

C. Francis Jenkins.

NOTICE

This booklet is printed primarily for distribution outside the membership of the Society of Motion Picture Engineers and so does not contain more of the minutes of the Chicago meeting than is thought would be of interest to the Industry at large.

The report and recommendation of the Committee on Optics, which was approved and adopted, appears herein. The other Committees reported progress in their work but asked further time for investigation before making recommendations, which later will doubtless appear in the Transactions of the next, the October, meeting.

The standards recommended herein are those which met the unanimous approval of the engineers present at the Chicago meeting; all subjects about which there was any difference of opinion being laid over for further consideration.

The few definitions herein are those which were adopted to be added to the definition of terms approved at the Atlantic City meeting, and which appear in the Transactions of that meeting.

REPORT BY THE COMMITTEE ON OPTICS TO THE SOCIETY OF MOTION PICTURE ENGINEERS

GENTLEMEN:

Your Committee on Optics begs to offer the following suggestions:

First: That the following focal lengths may be accepted as standard:

4	inches	6	inches
4–¼	"	6–¼	"
4–½	"	6–½	"
4–¾	"	6–¾	"
5	inches	7	inches
5–¼	"	7–¼	"
5–½	"	7–½	"
5–¾	"	7–¾	"
		8	inches
6	inches	8–½	inches
		9	inches

The small differences in magnification on the screen, caused by increasing the interval between the different focal lengths from ⅛" to ¼", are to be taken up by fitting the size of the screen mat to the size of the picture.

Second: That the opening in the lens support of the projection apparatus be made sufficiently large as not to diaphragm down the opening of the rear component of the projection lens.

Third: That the size of the opening of the aperture plate be 0.906"x 0.68".

Fourth: That the designers of motion picture theatres be enlightened on the causes of the so-called keystone effect, and that a deviation of 12° of the optical axis of the projection apparatus from the normal on the screen should be fixed as the maximum permissible limit.

Respectfully,

HERMANN KELLNER.

Chicago, July 17, 1917.

MOTION PICTURE STANDARDS

ADOPTED IN GOMMITTEE OF
THE WHOLE SOCIETY

The following have been adopted as standards by the Society of Motion Picture Engineers, and are promulgated to encourage uniformity and standard practice throughout the Industry as a whole. Their early universal adoption will save the industry a great deal of present annoyance and monetary loss.

Film speed—A film movement of sixty feet per minute through motion picture mechanisms shall be considered as standard speed.

Frame line—The dividing line between pictures on motion picture film, shall lie exactly midway between the marginal perforations.

Projection angle—The maximum permissible angle in picture projection shall not exceed twelve degrees (12°) from a perpendicular to the screen surface.

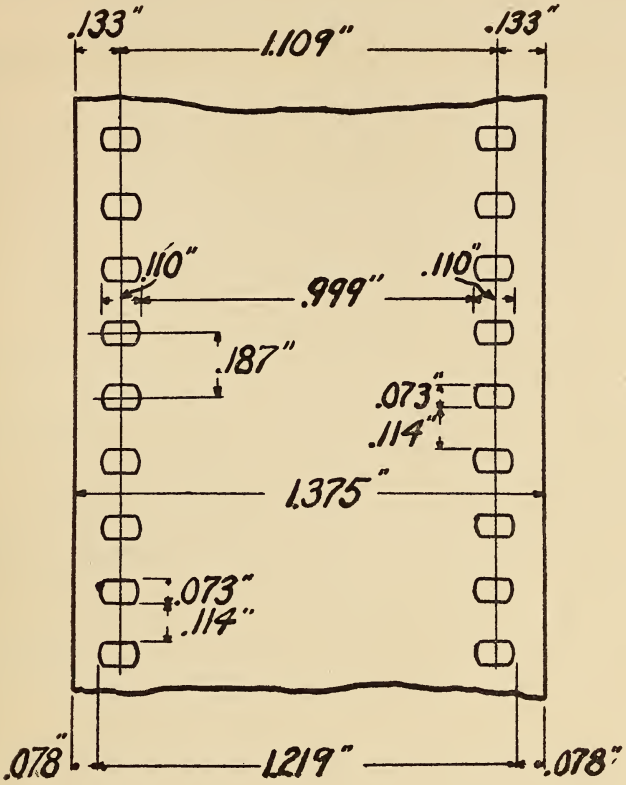
Projection lens foci—The Focus of motion picture projection lenses shall increase in ¼" steps to 8 inches and from 8 to 9 in ½-inch steps.

Projection lens mounting—Picture projecting lenses shall be so mounted that the light from the film picture aperture shall have an uninterrupted full path to the rear component of the lens.

Projecting lens height—The standard height from the door to the center of the projecting lens of a motion picture machine shall be 48 inches.

Picture aperture—The standard film picture aperture in a projecting machine shall be 0.906 inch wide and 0.6795 inch high, namely, 29/32" and 87/128".

Film perforation—The dimensions and location of film perforation shall be in accord with the illustrating diagram herewith.



Standard picture film—Shall be one and one-third inches wide, and carry a picture for each four perforations, the vertical position of the picture being longitudinal of the film.

Lantern slide mat opening—A standard opening in mats of lantern slides for use in conjunction with motion pictures shall be 3 inches wide by 2¼ inches high.

Thumb mark—The thumb mark spot on a lantern slide shall be located in the lower left hand corner next the reader when the slide is held so as to be read against a light.

Lantern strip—A red binding strip to be used on the lower edge of the lantern slide.

MOTION PICTURE NOMENCLATURE

ADOPTED IN GOMMITTEE OF
THE WHOLE SOCIETY

Condensers:

Collector lens—the lens next the source of light.

Converging lens—the lens which converges the light on the picture aperture.

Middle lens—of a three-lens combination, the lens lying between the arc lens and the converging lens.

Frame line—The dividing line between two pictures on a motion picture film which forms the top and bottom respectively of adjacent pictures.

Leaders—That piece of blank film attached to the beginning of the picture series.

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

MEETING of OCTOBER 8-9, 1917

NEW YORK CITY

NUMBER FIVE

TWENTY-FIVE CENTS

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SOCIETY OF MOTION PICTURE ENGINEERS

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OCTOBER, 1917

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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers stands for unselfish service to the Industry. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts; and an Associate Member is one who, though not eligible to membership in the active class, is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least two members in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All aplications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee for all members shall be twenty-five dollars ($25.00). The annual dues shall be ten dollars ($10.00), payable in advance before the annual meeting (October) of each year. That is, the total fee for the first year, which includes the entrance fees and first annual dues, is $35.00 for all members.

PRESIDENT'S ADDRESS

October 8, 1917.

GENTLEMEN:

This is our anniversary gathering. The Society of Motion Picture Engineers is just a year old. From a haudful who met in Washington a year ago in July to prepare for its consummation in October, this Society has grown by the addition of other men earnestly and unselfishly laboring for the good of the industry. This growth has been an accelerating one as the honestly skeptical became more and more convinced of our integrity of purpose and solidity and permanency of organization.

May I also remind you of a fact of which I am likewise proud, i. e., that our meetings have been harmonious, doubtless because only gentlemen have been in attendance. All discussions have been constructive. No criticism has been made at any session which was not at once followed by constructive suggestions. No one impuned a wholly selfish motive in the remarks of any speaker. The apparent purpose of each member in attendance has been to take action of value to the industry as a whole. This is well, for along that line only is progress, and growth, strength and respect for our Society.

We have accomplished much already and will do a great deal more. But if we had done nothing further than establish a standard frame line it would have been worth all the time and effort and expense attendant thereupon.

Let me illustrate: Some time since the Federal Government sent two camera men into our great National Parks to take motion pictures of the beauties and wonders therein, the giant geysers, lofty waterfalls, mirror lakes, and the like. I was asked to a private showing of these pictures, and found the photography of both men so good that the work of each was spliced into that of the other without a discordant tone, but the ensemble as a whole was horrible, for one camera framed on perforations and the other between. The projecting machine man, at first, tried to frame as fast as these misframes occurred, but soon gave it up as impossible and the audience was the loser. A beautiful picture ruined, and much time and money wasted, all because two cameras with different frame lines were used on the same work. Let us hope the pictures made of this great war by Government photographers may not be like that. Perhaps they will respect our recommendations and adopt a standard frame line in all their cameras.

As a Society we can only recommend; we are not either a legislative, executive, or judicial body. Nor is our Society trying to compel anybody to do anything. For example, it is not trying to legislate a given film speed, or to require every mechanism to be run at this speed. It has no such power and no such desire.

Recommendations of the Society as to a standard in any given case simply reflect the concensus of opinion of the engineers of our industry. Anyone may run his apparatus faster or slower than this standard, but because it is a standard the inquirer has something to use as a basis for intelligent discussion of the subject. He is able to say that a camera running at 66 feet a minute is running 10% above the standard, and which some may prefer in an exciting war scene, or 54 feet per minute, i. e., 10% below standard, which may work out better for a slap-stick comedy scene.

It is the same with regard to the size of the aperture, as another example. One projector manufacturer chooses a ¾" height, another prefers ⅝" perhaps, and there is nothing to prevent either from making the aperture what he pleases. But the recommendation of this Society is that, for uniformity, all apertures be .678" high, and as this is therefore likely to be adopted by many the way is smoother for all if each conforms to this standard. That is all there is to it.

I think if we keep this point of view clearly in mind our work will be better understood and more appreciated by all, for we are only making recommendations looking toward very desirable uniformity in the industry, with its resultant advantages.

Similar standardization is what has made the automobile industry, and yet I remember when there were fourteen different tire valve nipples, and stopping at a "horseless carriage" repair shop did not always mean one could get air in one's tire; the shop might have but thirteen of the fourteen, and mine was the other one.

I really don't think our industry was ever as bad as that, perhaps, but the floating frame line has been a nightmare to many a projection machine operator.

Just a further word, an apology, and I stop, for we have much that is important to do at this meeting. If the work of the past year has seemed to be dominated by your president it was only because it seemed necessary in order to get much needed work done. Or if this has given offense to any fellow member, it certainly was unintentional and I shall have sincere regrets when I learn of it. There is precedent for it, of course, for every successful organization must have a final judicial head, who must take the deciding action, even though backed by an advisory body of no mean attainments. I have had hearty cooperation and valuable assistance from many of you and take this opportunity to publicly thank each of you. I trust that you will continue similar support of your next president, whoever he may be, and that the standards we have set may be universally accepted, to the good of the whole industry.

Ultimately I want to see the Society of Motion Picture Engineers an international association, with world objects for world good.

C. Francis Jenkins.

MOTION PICTURE STANDARDS

ADOPTED IN COMMITTEE OF
THE WHOLE SOCIETY

The following standards, in addition to those previously adopted as standards by the Society of Motion Picture Engineers, are promulgated to encourage uniformity and standard practice throughout the Industry as a whole. The early universal adoption of all of them will save the Industry a great deal of present annoyance and monetary loss.

Projection lens opening—The diameter of unit opening for projecting lens holder shall be 1 15-16 inch.

Projection objectives—Shall have the equivalent focal length marked thereon in inches and quarters and halves of an inch, in decimals, with a plus (+) or minus (—) tolerence not to exceed 1 per cent of the designated equivalent focal length also marked by the proper sign following the figure.

Reel—The approved standard reel shall be 11 inches in diameter; 1½ inches inside width; with 5-16-inch center hole, with a key-way ⅛" by ⅛" extending all the way through; a 5-inch hub; and a permissible flange wabble of not more than 1-16-inch.

Standard reel of film—Shall have black film leaders, with tinted (red, green or blue) trailers; should have marking thereon embossed rather than punched in the film; and each reel of a multiple reel story should end with a title, and the next reel begin with the same title.

Take-up pull—The take-up pull on film shall not exceed 15 ounces at the periphery of a 10-inch reel or 16-ounces on a standard (11-inch) reel.

MOTION PICTURE NOMENCLATURE

ADOPTED IN COMMITTEE OF
THE WHOLE SOCIETY

change-over—The stopping of one projecting machine and the simultaneous starting of a second machine in order to maintain an uninterrupted picture on the screen when showing a multiple-reel story.

dissolve—The gradual transition of one scene into another.

double exposure—The exposure of a negative film in a camera twice before development.

double printing—The exposure of the sensitive film under two negatives prior to development.

fade-in—The graduation formation of the picture from darkness to full screen brilliancy.

fade-out—The gradual disappearance of the screen-picture into blackness. (The reverse of fade-in).

footage—Film length measured in feet.

panoram (verb), **panorama** (noun)—The act of, or device for, turning a motion picture camera horizontally, to photograph a moving object, or to embrace a wide angle of view.

single picture crank—(sometimes referred to as trick spindle)—The spindle and crank on a motion picture camera which makes one exposure at each complete revolution.

tilt—The act of, or device for, moving a camera vertically while in use.

vision—A new subject introduced into the main picture, by the gradual fading-in and fading-out of the new subject, as, for example, to visualize a thought.

OFFSET PROJECTION

WILL G. SMITH

When a projecting machine is set in any other position than directly opposite the center of the picture screen, in other words, when the projecting machine is "offset" from the center of the screen, certain highly undesirable effects are produced in the picture. These undesirable effects are of two kinds, first, blurring of certain edges of the picture and, second, distortion of the objects appearing on the screen.

Taking up the first of these effects, blurring of the edges, this is seen to be due to the fact that one edge of the screen is further from the lens than the other edge, and, consequently, if any chosen part of the picture is "focused" clearly on the screen other parts of the picture must, of necessity, be "out of focus." When the "offset" of the projecting machine from the screen center is not greater than, say, 5° to 10° then the blurring effect is not particularly noticeable, but when, as in some theatres in present use, the angle is as great as 35° it is utterly impossible to produce a clear picture of any attractive size.

The second of the ill effects of "offset" projection, the distortion of the objects shown, is due to the fact that the light beam coming from the projection machine to the screen is cone shaped and grows rapidly larger in area as the screen is approached. Consequently, if a section is taken through such a light cone at an angle, then, since one edge of the section plane cuts a narrower part of the beam than the other edge, it follows that one edge of the picture will be larger than the other; and further, since the further the cutting section is taken from the lens the larger the projection is, it follows that the same object moving to different positions in the picture will undergo a change in size.

Considering now a special case, which is perhaps the most common case of "offset projection," let us consider that the projecting machine is placed in the balcony of a theatre directly in line with the center of the screen on the stage but considerably above it. Then the light cone will come down to the screen and strike at an angle and the following undesirable effects will be apparent:

1. The top and bottom of the picture will be blurred while the middle will be clear.
2. A body moving from the top to the bottom of the picture will become considerably larger.
3. All vertical objects will be large at the bottom and small at the top—for instance, a man will have big feet and a small head.
4. All objects will be abnormally tall.

When the projecting machine is horizontally in line with the center of the screen but a considerable distance to one side or the other of it, then the same distortions are present in the picture, but with some difference, as follows:

1. The sides of the picture will be blurred while the middle will be clear.
2. A body moving from one side to the other of the picture will become larger or smaller.
3. All horizontal objects will be larger at one end than at the other.
4. All objects will be abnormally long.

In some theatres the projecting machine is offset both horizontally and vertically, in which case the picture shows evidence of both kinds of distortion described in the special case above.

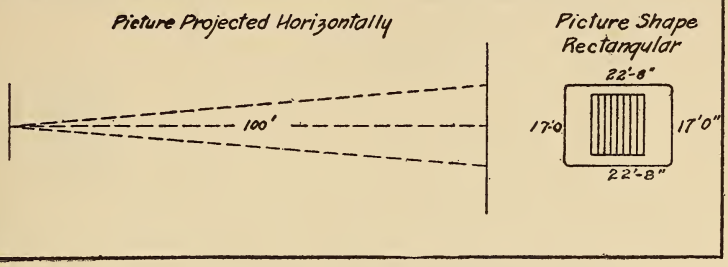
There have been certain attempts made to correct the bad effects of "offset projection" but, owing to the fact that offset projection is basically wrong, these methods have proved far from successful. These corrective methods consist in:

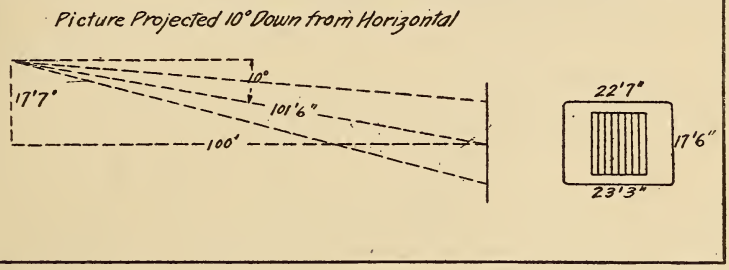
1. Filing the aperture plate of the projecting machine, and thus giving the light cone a distorted shape previous to its reaching the screen—the result of this distortion and the natural distortion being neutral and thus having a picture with a correct border line. **But, it should be noted that this method does not in any way correct the distortion actually within the border.**
2. Showing a small picture high upon the screen. The disadvantage of this method is apparent.
3. Tipping the screen one way or the other. This method makes the picture hard on the eyes of the audience and is, consequently, little used.

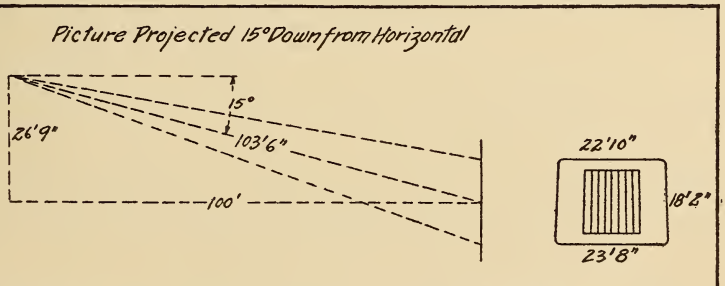
In conclusion it may be stated that there is at the present time only one way of preventing the ill effects of "offset projection" and that is to eliminate the "offset," in other words, to place the projecting machine nearly opposite the center of the screen.

DWG. No. 200-1

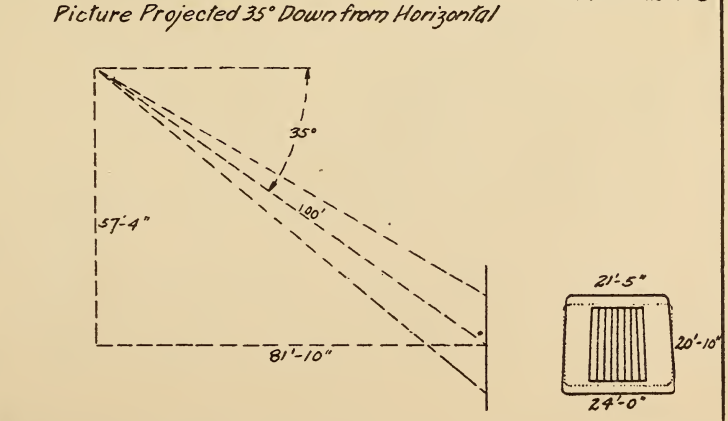
OFFSET PROJECTION
EFFECT ON PICTURE

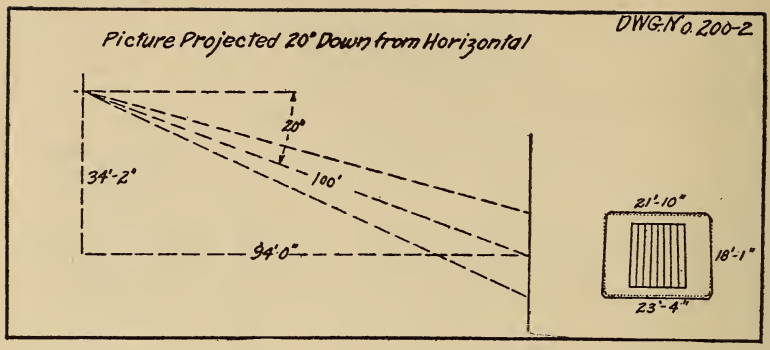


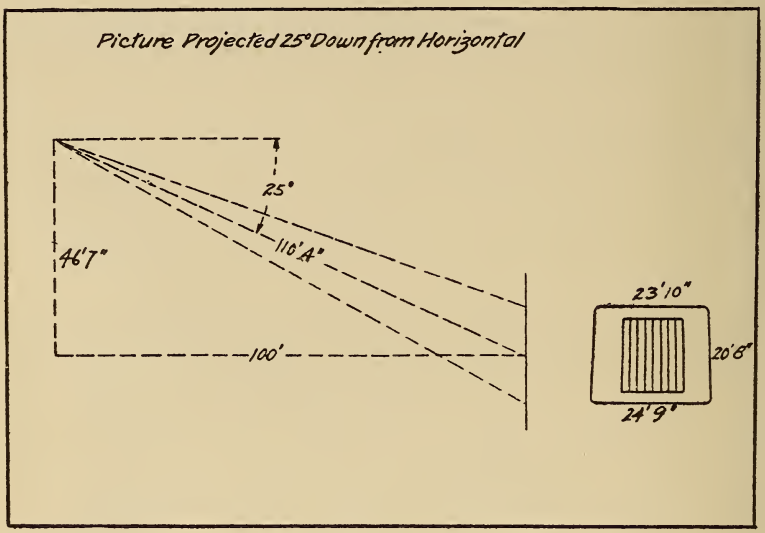


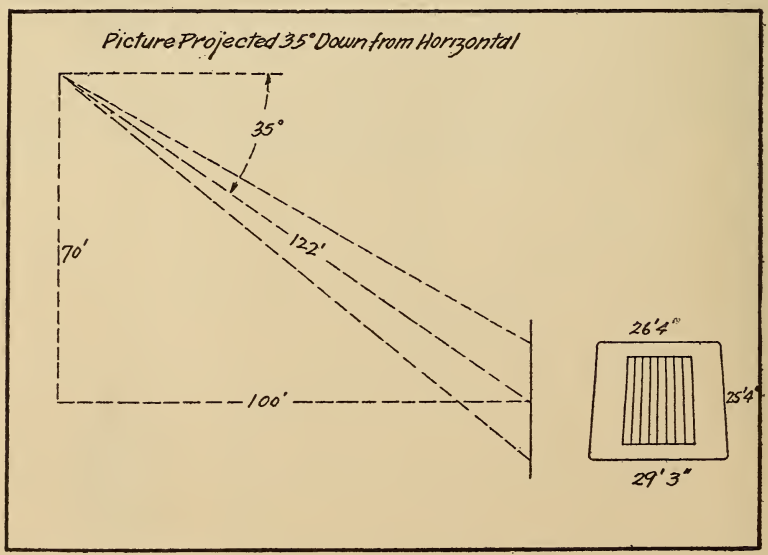


DWG. No. 200-3




Picture Projected 20° Down from Horizontal
DWG. No. 200-2
20°
34'-2"
100'
94'0"
21'-10"
18'-1"
23'-4"


Picture Projected 25° Down from Horizontal
25°
46'7"
110'4"
100'
23'10"
20'8"
24'9"


Picture Projected 35° Down from Horizontal
35°
70'
122'
100'
26'4"
25'4"
29'3"

THE MOTION PICTURE BOOTH

C. FRANCIS JENKINS

The motion picture booth was inaugurated several years ago when motion pictures began to be used in "Picture Parlors." The pictures were popular and the demand for projecting machines grew faster than the supply with the result that even the poorest kind of machine was saleable.

These poor machines with half inclosed arc lamps and the tissue-like film, only then available, was the cause of too frequent fires.

A still further factor of hazard was the type of man who first took up the public exhibition of this new show device, a type of man who did not build solidly and for the future but for a "front" and the quick dollar.

So to confine the fire which was almost sure to ensue sooner or later from this combination of flimsy machine, tissue-like film and careless handling, the fire authorities of a large city inaugurated the booth inclosure of metal or asbestos and the regulation was more or less copied by other cities, the idea being to confine such fire as might occur.

But as years passed the machines improved and the film was strengthened, until today the film is twice as thick as it was at first, and machines are now available which totally inclose the film at all points. The machine manufacturer has, therefore, gone about as far as he can go, and it is squarely up to the authorities to make the handling of the film safe, and this can be done most successfully by making the operator work in sight all the time.

The modern machine and film is not a hazardous combination. Whatever danger there is today comes about by the operator fastening the magazine doors open, by smoking, by failure to immediately return the film to its metal container when taken from the machine magazine after its showing, and such like disregard of ordinary caution. This is recognized by municipal authorities and regulations to this effect are almost universal.

But laws will no more stop such practices than laws will prevent theft; and we all unconsciously confess, daily, that, better than law, the way to protect one's personal property is to watch it.

For the same physiological reason the projection room should be wire-glass-walled on two, or three, sides. And also because it would please the skilled, conscientious operator who is proud of his work and workroom, and it is only fair that this justifiable pride should be rewarded by easier public observation.

The concealing booth is an anomaly, anyhow. In no other human employment involving public hazard is the operator concealed from observation. In driving taxicabs, we put tags on the driver and the machine, "so we can get his number"; instinctively we avoid dark streets, so as not to invite danger from the slinking thug; and even when we put a night watchman to watching a building we put a clock to watching the watchman.

But when it comes to motion pictures, we reverse this natural custom and at least hang around the operator a shower-bath curtain so that nobody can watch him. It would be funny if it did not involve danger, for a booth isn't a factor of safety; on the contrary, it is a hazard, because it invites negligence, or worse.

When this established principal is recognized by our authorities and booths required which do not conceal the operator, the motion picture projector manufacturer will be released from blame for film fires, and we will quickly arrive at a time when "booth fires" will be a thing of the past.

It seems much more sensible to prevent fires than to employ means to confine them when such means only invite a conflagration. Picture film of itself is not unsafe. It does not evaporate and give off inflamable vapors like gasoline nor will it ignite spontaneously, as is proved by the thousands of rolls of picture film on the shelves of photo supply stores all over the world. Tons and tons of it is made daily in Rochester alone, but they have never had a film fire, for all operatives work in the open.

Picture theatre booths should be constructed with the front wall opaque so that the audience may not see or be disturbed by what is happening in the booth, as now arranged, but the booth should have the sides and rear wall of wire-glass, or some such plan as will give an unobstructed view of the inside of the booth at all times, by the owner, by inspectors, and others. (Just why booths are not provided with that excellent fire enemy, the sprinkler system (with inch heads), is inexplicable to me).

In temporary installations, certainly, the safest plan is to do away with the concealing booth entirely. It is much wiser to require the handling of the film in the open, and where the operator has ample room to work safely, than in the confined space of a shower-bath curtain booth. It may be contended that the curtain is to prevent panic, but one has but to remember that no temporary booth could confine the smoke of burning film, and smoke has caused more panic than fire ever has. Whereas, on the other hand, if there were no booths there would be no fires, where a safe machine is employed.

The concealing booth is a source of unnecessary hazard and the cause of more fires than ever have been prevented thereby, and should, therefore, be done away with.

Daily the picture film is coming more and more to be recognized for what it is, the greatest of all teachers. It speaks the only universal language. No other device equals it for conveying a message, and probably never will.

The invention of the printing press, in the 15th century, gave a tremendous impetus to learning, but it appealed only to a class, for it was limited to those who can read. The invention of the motion picture of the 20th century began a second and greater era of learning for it speaks to the masses as well; to the old and young, to the illiterate as well as the learned of every tongue, and it should not be forgotten that the illiterate of our earth constitute a body many times greater than those who can read. Again, the printing press must print for each man in his own tongue, while the motion picture prints in a language all can read. The printing press is autocratic, the motion picture democratic.

The immeasurable opportunity for good in the new picture press is rather rapidly coming to be recognized, I am happy to say, but it would go forward with greater stride if the handicap of the unnecessary, hazardous concealing booth, for the classroom, lecture hall, or outdoor gathering, could be removed without delay. Ultimately this requirement will become obsolete and a dead letter just as the prohibition to automoblies aboard ferry boats, but teaching would be the great gainer if this could come soon.

Let us remove unnecessary obstructions to the rapid and wide use in the school room of so wonderful a teacher; and also give to the motion picture in theatres a better name by the use of a glass booth.

REPORT OF COMMITTEE ON ELECTRICAL DEVICES

H. M. WIBLE, Chairman
W. G. KUNZMANN
H. A. CAMPE
MAX MAYER
J. G. MOULTON
ROBT. P. BURROWS

The Committee on Electrical Devices have made an investigation of the various forms of converting equipment for use in operating D. C. arcs from A. C. mains and submits for your approval the following report, which intends to show the characteristics and advantages of each of the forms. Information has not yet been secured on all of the devices on the market and this report, therefore, does not include the entire list.

The ultimate purpose of such an investigation is to determine the principles by which the selection of apparatus for any installation may be made. Briefly summarized, the data submitted by the several manufacturers result in the general principles stated below.

Owing to the lack of data, it has been necessary to limit the recommendations for application to Mercury Arc Rectifiers and Motor Generator Sets, but it is probable that the same considerations applying to the Motor Generator Sets will apply to Rotary Converters in a general way.

Either type of equipment will give satisfactory service when properly installed and cared for as directed. The question as to which piece of apparatus should be adopted should properly be determined by the local conditions of the individual application.

The arc current required is determined by:

(a) Dimensions of screen
(b) Length of throw
(c) Reflective value of screen
(d) Intensity of general illumination
(e) Angle of projection
(f) Type and density of film.

Information to be taken into consideration in selecting one equipment where either may be applied is listed below:

(a) There is a difference in over-all efficiency between the Motor Generator Set and rectifier.

(b) The first cost, including installation, is lower for the rectifier.

(c) The rectifier may be and usually is installed in the operator's booth.

(d) In cases where it seems necessary that both arcs be operated simultaneously for any purpose, the Motor Generator is the proper equipment. Some theatres operate two machines from a single rectifier by stealing the arc from one machine to the other, without any warming-up period.

Mercury Arc Rectifier Equipment.

The equipments now made for this service differ only in details and the descriptions of the outfits are, therefore, combined for sake of brevity, and mercury arc rectifiers have been recognized as standards for a number of years.

The equipments now made consist of a transformer regulating reactance, a bulb or tube, control mechanism, and an automatic starting device. The transformer and regulating reactance, which may be included as part of the transformer, are for the purpose of reducing the line voltage to the proper value and provide stability of the arc. The bulb or tube serves as an electrical valve, which prevents the flow of current in the wrong direction. The connections are such as to utilize current from two different parts of the transformer winding in such a manner as to secure continuous current, and the transformer is so designed that the pulsations are slight.

In order to compensate for variations in line voltage and to permit adjustments to be made to take care of variable conditions, such as film density, etc., means are provided for controlling the current, by changing connections of the reactance or transformer. These outfits are so arranged as to permit the operation of an A. C. arc as an emergency measure.

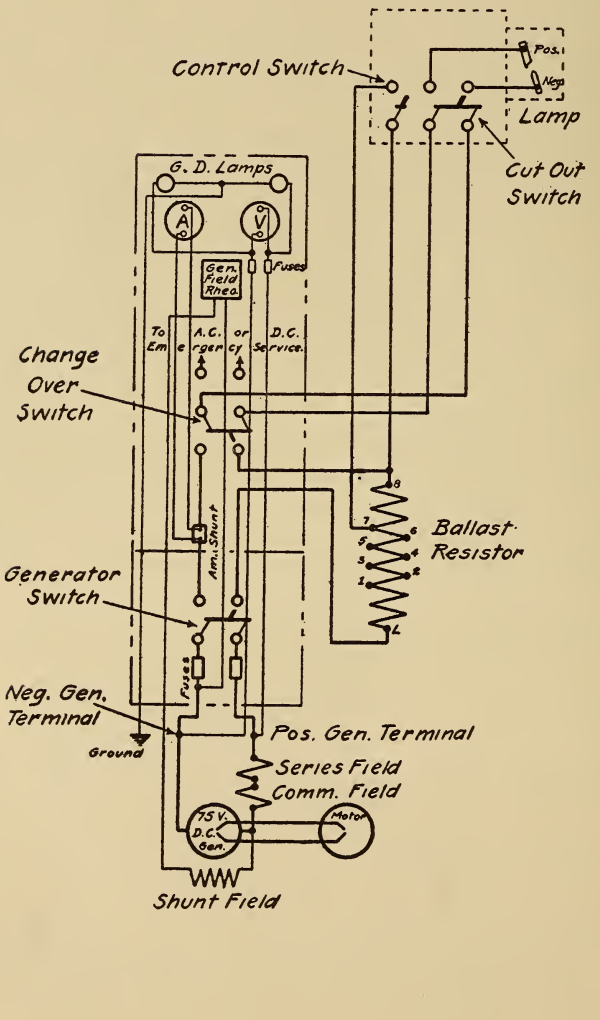
For convenience in operating and to permit the installation of the outfit at some distance from the operator, automatic starting devices are provided. These are such that the outfit is started by closing the line switch and striking the arc.

The over-all efficiency of the rectifier is approximately 70%. This represents the percentage power from the line, which is delivered in the form of power to the arc.

All outfits are designed so as to operate at full load continuously without temperatures that are unsafe.

Mercury Arc Rectifiers are made in 30, 40 or 50 D. C. amperes capacity, and can be made for service on any commercial A. C. circuit. The inherent characteristics of all outfits are such as to make the arc voltage at normal current highly efficient.

Motion Picture Equipment
SINGLE LIGHT
Schematic Connections
Panel provided for Emergency Service



MOTOR GENERATOR EQUIPMENT.

Those investigated, and on which your Committee is prepared to report, consist of two general A. C. to D. C. types which may be classified under the headings of:

Constant Current
Constant Potential
also
D. C. to D. C. Types.

Constant Current Equipment—A. C. to D. C.

The A. C. to D. C. equipment is a straight motor generator set of a standard alternating current induction motor direct connected to a special D. C. generator. Both units are mounted on a common bed plate, forming a three-bearing set.

This equipment is built in three sizes—35, 50 and 70 amperes. These machines are designed to handle one arc continuously, and two arcs for a short period of time when changing over the pictures. During the process of changing over, when two arcs are burning, they are connected in series across the armature of the generator. The 35 ampere machine is designed to run one lamp at 35 amperes, 55 volts, and two lamps at 35 amperes, 110 volts. The 50 ampere machine is designed to run one lamp at 50 amperes, 60 volts, and two lamps at 50 amperes, 120 volts. The 70 ampere machine will operate one lamp, 70 amperes, 65 volts, and two lamps at 70 amperes, 130 volts.

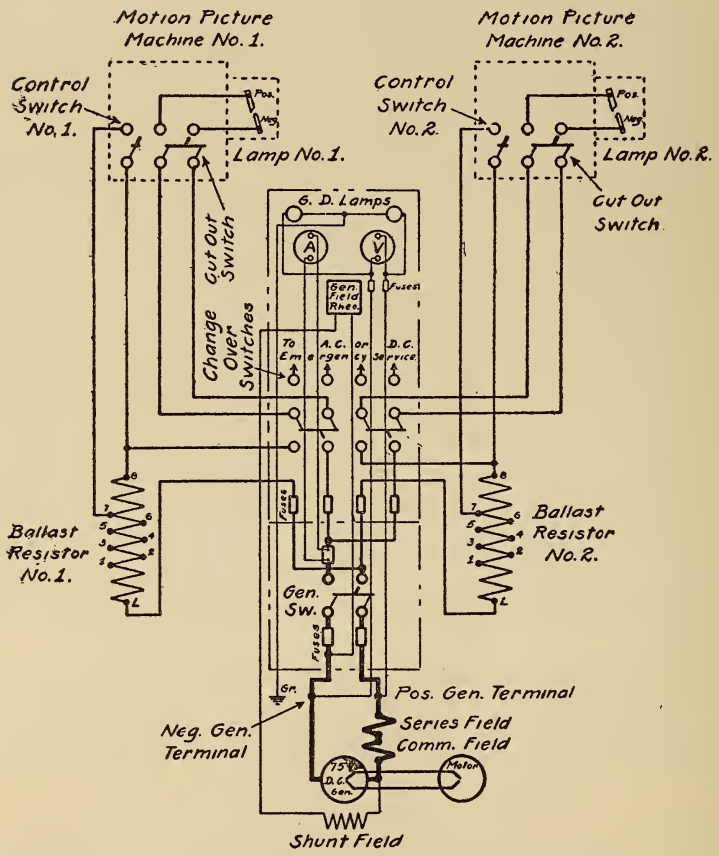
These machines have an over-all efficiency of approximately 70% at their rated load. They will operate continuously under full load to a temperature rise not to exceed 40 degrees Centigrade, two hours at 25% overload, with temperature rise not to exceed 55 degrees Centigrade. They can be built for any commercial alternating current circuit, as standard induction motors are used.

The equipment includes the motor generator set complete, a steel panel, on which is mounted an ammeter and generator field rheostat. Two short-circuiting switches are also supplied, the function of which is to short circuit the arc which is not burning.

Operation.

After the set is up to speed, the generator field rheostat is turned to a marked point, and one arc is short circuited. The other arc is struck in the usual manner. The voltage of the machine will automatically drop to that required by the arc depending on the current used. When ready to change over, the carbons of the second lamp are brought together until they touch, the short-circuiting switch is opened, and the carbons gradually separated. The voltage of the machine will automatically increase to take care of the added resistance, holding the current

Motion Picture Equipment
TWO LIGHT
Schematic Connections
Panel provided for Emergency Service



Extra Heavy Lines indicate Wires which must carry Current for Both Lamps. For size of these Wires see Table 1.

constant. To shut down the first arc, close the short-circuiting switch.

The D. C. to D. C. equipment is not a true motor generator set, but very closely resembles a balancer set. Both armatures are mounted on a common shaft, making a two-bearing outfit, the two armatures being connected in series across the line. The arc circuit is taken from a connection between the armatures and side of the line. This volt ampere characteristic is such that one lamp can be operated from this machine without the use of a steadying resistance. The machine, therefore, not only lowers the line potential to that suitable for the projection arc, but allows the arc to be operated in a highly efficient manner.

The D. C. to D. C. outfits are built for 35, 50 and 70 ampere one lamp equipments, and 35 and 50 ampere two lamp equipments. The two lamp equipments are designed with a compound field which is cut in service when two lamps are operating. The two lamps are connected in multiple across the armature of the machine; the machine very closely resembling a constant potential generator.

With the two lamp equipments there is furnished a special panel which contains an ammeter, voltmeter, generator field rheostat and a change-over switch. The function of this change-over switch is to cut in the series field on the generator, changing its characteristic so as to allow the operation of two lamps. It is, however, necessary to use a slight amount of steadying resistance with this type of outfit when operating two lamps. This is because the outfit is practically a constant potential generator. Due to the use of the steadying resistance, the overall efficiency is lowered about 18% when operating two lamps, 70% one lamp.

Operation.

The method of operating the D. C. to D. C. outfit is as follows:

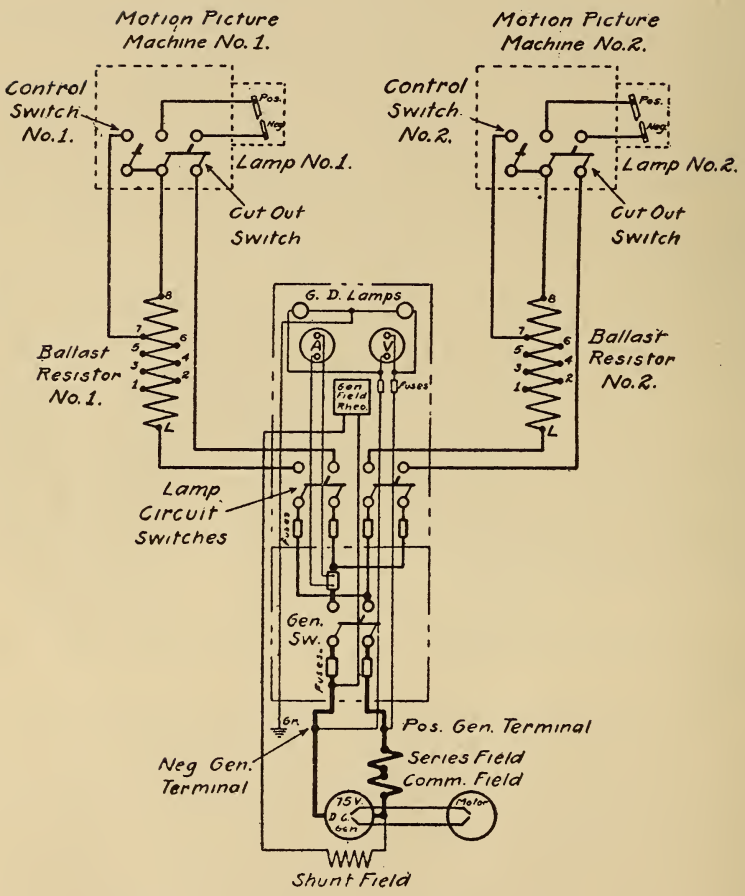
After the set is up to speed with the change-over switch on the panel closed, the first arc is struck in the usual manner. When one arc is burning, there is no steadying resistance to be used. When ready to change over, to include the second arc, the short-circuiting switch is opened, which automatically cuts in the series field of the generator and at the same time inserts a steadying resistance in series with the arc. The second arc is then struck. When ready to shut down the first arc, the arc switch is opened and the change-over on the panel closed.

The single arc D. C. to D. C. outfit consists of a motor generator complete with motor starter and generator field rheostat.

Constant Potential Equipment.

The motor generator sets built for this service each comprise a 75 volt compound wound commutating pole direct current

Motion Picture Equipment
TWO LIGHT
Schematic Connections



Extra Heavy Lines indicate Wires which must carry Current for Both Lamps. For size of these Wires see Table 1.

generator, directly connected to and driven by a suitable motor, both units being mounted on a common cast iron bed plate or sub base. They are built in four capacities, namely, 40, 55, 70 and 90 amperes. Sets, the motors of which are for single phase service or for direct current service, are of the four bearing rigidly coupled type, whereas all others are of the common shaft type. The motors of all three phase sets, except the 40 ampere rating, have six leads so that the motor may be star connected for starting, and delta connected for running, thereby eliminating the necessity of using a regular auto transformer for starting, with a reduced voltage at the motor terminals.

Motors for any standard commercial electric circuit can be readily supplied, as all motors used are of standard construction and characteristics.

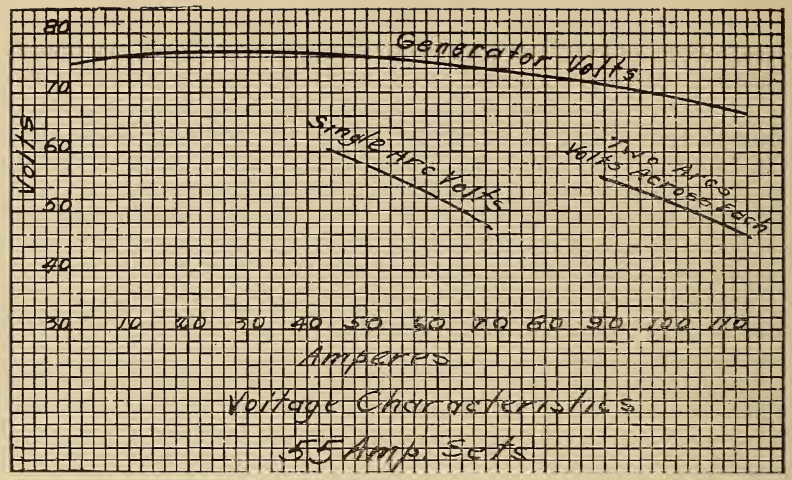
The over-all efficiency of the various sets is approximately 70% when developing full rated capacity. The sets will operate continuously, delivering rated capacity at a temperature rise not exceeding 40 degrees Centigrade, and also are capable of delivering 125% of rated capacity for a period of two hours, at a temperature rise not exceeding 55 degrees Centigrade. Each set also will develop sufficient energy to operate two motion picture machines simultaneously during the change-over period, when one reel of picture is being finished and the subsequent reel is being started.

A complete motion picture equipment comprises a motor generator set, a ballast resistance and control switch for each motion picture machine, a control panel for the generator, and a starter, if required, for the motor. These equipments are usually connected as indicated in Figures No. 1 to No. 4, inclusive.

Operation.

The motor generator set is started in the usual manner, after which the necessary switches are closed in the direct current circuit, so that the arc may be struck in one of the motion picture machines. The voltage developed by the generator and the voltage across a single arc is indicated by Curve No. 5. The arc can be struck in the second motion picture machine when desired, but the control switch for that circuit should be opened prior to striking the arc. Opening the control switch establishes a circuit whereby all of the ballast resistance for the lamp is in series with the arc, and thereby preventing an abnormal rush of current through the lamp when the arc is struck. This also prevents any disturbance of the light produced by the other lamp. As soon as the new arc is well established, the control switch may be closed whereupon the voltage characteristics of the generator and arcs are indicated by "two arc volts," and "generator volts" indicated by Curve No. 5.

Each ballast resistance is provided with taps so that the current delivered to the arc may be readily adjusted for any value required within the capacity of the equipment.



The constant potential equipments, such as have been described above, have proven to be admirably well adapted for motion picture service, especially in districts where the power supply for the motor is subject to variations, resulting in changes of speed in the motor generator set. This is due to the fact that the ballast resistance in series with each arc compensates for any voltage changes of the generator, due to speed fluctuations. As a result, when the generator voltage decreases, due to a decrease of speed, the voltage drop across the ballast resistance also decreases, due to a comparatively small decrease in current, which results in a higher voltage across the arc, and, therefore, the watts dissipated in the arc remain more nearly fixed, or constant. As a result of these conditions, the intensity of the light generated by the arc remains more nearly constant than it will for an equipment operating under the same conditions, and feeding the arc directly from the generator without the use of a series resistance.

It is unfortunate that the Committee's efforts to secure information from all of the manufacturers met with such incomplete co-operation, and it is the Committee's suggestion that better results could be secured if a more definite effort were made to advertise the Society and its aims. The attitude of some of the manufacturers seems to be founded on the lack of faith in the motives of the Society, which can only be overcome through the united efforts of the Society.

The Committee earnestly requests that the administration of this Society take this situation under consideration and make immediate and continued efforts to overcome it, if the work of the Committee is to continue. Suggestions and criticisms are solicited from various manufacturers.

THE PROJECTION OF MOTION PICTURES BY MEANS OF INCANDESCENT LAMPS

A. R. DENINGTON

FILAMENT ARRANGEMENT:

In the development of a lamp suitable for the projection of motion pictures, it is essential that the light source be concentrated as closely as possible. After a number of experiments on filament arrangement, there have been developed two forms of filament for incandescent lamps for motion picture projection. The first successful arrangement of the filament was in two rows with coil sections parallel to each other, the coils in the second row of filament being placed so that they came between the coils in the first row. This arrangement gives the appearance of a solid source of light from a position directly in front. However, the condenser picks up light from all points within an angle of thirty to forty degrees from the line of projection. The edges of the condenser therefore pick up light from the front row of coils and those portions of the coils in the back row which are not obscured by the coils in the front row. By means of the biplane arrangement, however, it is possible to obtain a greater amount of filament within the area which can be effectively used by the condenser; the useful area with practically any condenser system being not greater than ½" square. If a spherical mirror is used back of the biplane coil, the reflected images make it possible to obtain a uniform screen.

The other system of coil arrangement consists in placing the coils in a single plane at right angles with the line of projection. This arrangement is commonly spoken of as the monoplane arrangement. With this arrangement of the filament coils, a spherical mirror is so focused that the coil images come into the spaces between coils, thus giving a fairly uniform source of light. However, with this arrangement of coils, there is an appreciable difference between the light received from the coils themselves and that received from the coil images, thus making a less uniform source of light than is obtained with the biplane construction.

CONDENSER SYSTEMS:

There are two condenser systems which are being used in the projection of motion pictures by means of gas-filled incandescent lamps. The usual plano convex condenser system which has been in use with the arc lamp was found to have some disadvantages, the principle disadvantage being the non-uniformity of illumination of the screen. With a plano convex condenser system there is a tendency for vertical bands to appear on the

screen. These vertical bands are the more or less imperfect images of the coils. By careful arrangement of the condenser and correct focusing of the lamp, these vertical bands can be made almost indiscernible on the plain screen and entirely invisible when a picture is being shown. The plano convex condenser system possesses the advantage of giving plenty of working room between the lamp house and the machine head. As the rays of light do not converge as rapidly as with the corrugated type of condenser, it is also possible where objectives of long focus are used, to get a greater proportion of the light which passes the film through the objective and on to the screen. There is also an added advantage which is of importance in the small theatre where the motion picture machine is relied upon for projecting slides, because the same condenser system can be used for projecting the slides and the film.

The screen illuminated by means of the plano convex condenser has a somewhat higher intensity at the center than at the edges. This difference, however, is not great enough to be noticeable, the average illumination in the center portion of the screen being in most cases not more than 50% higher than the illumination, measured about six inches from the edge of the screen.

The corrugated condenser which has been developed in two sizes, possesses the disadvantage of bringing the light source very close to the head of the motion picture machine, thus limiting the working space for the operator. With many machines which are in service at the present time, it is necessary to reach between the lamp house and the motion picture machine head in order to move the framing lever. It is, of course, in the interests of good projection that the film be so perfect that the framing lever need not be adjusted while the film is being run. However, the conditions which actually exist necessitate frequent adjustment of the pictures, in order to frame it correctly. The advantage of the corrugated condenser is a uniformly illuminated screen. The condenser is designed to pick up a large angle of light from the light source, but a portion of this is lost, especially at the outer edges of the condenser by surface reflection and dispersion from the molded glass. This point can be verified by holding a card in front of the machine at such a distance that the image of the condenser is formed on the card. It will be noted that the outer rings appear much darker than the central rings. There is also some loss at the apex of each ridge or ring. The light converges at a sharper angle than with the plano convex condensing system, and therefore a portion of it may be lost after passing through the film, because the objective may not be large enough to pick up the cone of light. In fact, practically all of our tests show that a higher illumination can be obtained on the screen by means of the plano convex condenser, than by means of the corrugated condenser.

OBJECTIVE LENS:

The objective lens used in the projection of pictures by means of incandescent lamps should be of wide aperture to pick up as much as possible of the cone of light which is passed through the film. In most of the projectors, the diameter of the lens holder is about 2″, and the lens which is greater in diameter than 2″ must therefore be held in a special adapter or mounted in a jacket on the face plate of the machine. In any event, the cone of light which passes to the lens cannot be greater in diameter than the tube or opening in which the lens is mounted. Increasing the diameter of the lens beyond about 2½″, would therefore seem to be of doubtful value for existing equipment.

SCREEN RESULTS:

A number of tests of the illumination delivered to the screen, show that an incandescent lamp can be depended upon to deliver fully 600 lumens on the screen. This means that the average illumination on a screen sixteen feet in width, will be in the neighborhood of three foot candles. Our tests have shown that this illumination will produce satisfactory pictures. In fact, the pictures, when compared with those produced by a 40 ampere direct current arc, were their equal in every way, and had the added advantage of being perfectly steady.

The average illumination produced by the arc in a test case was found to be 4.8 foot candles. This average was determined by taking readings every half minute during the period of ten minutes, while the operator held the arc as steady as possible. The variation in the arc was from about 2 foot candles to 9 foot candles, the variation seemingly being caused by the wandering of the arc and by the necessity for trimming it occasionally. The measurments in both cases were taken with the shutter open. The projection distance was 112 feet.

LIGHT INTENSITIES FOR MOTION PICTURE PROJECTION

J. T. GARDWELL FOR R. P. BURROWS

I have been invited to address you on the subject, "Light Intensities for Motion Picture Projection"—a subject which is ot very real importance but concerning which there is a scarcity of data. The best I can do, therefore, is to discuss the factors affecting light intensities and draw from this discussion tentative conclusions for your consideration.

First of all, it is of interest to note that the eye sees a picture on the screen not by the light which strikes the screen, but by the light which the screen reflects to the eye. If we imagine a perfectly black screen, one which reflects no light at all—we see at once that no matter how strong the beam we project on the screen we will obtain no picture at all. Screens used in practice vary in reflection factor; that is, in their power to reflect light, through very wide limits; hence it is obviously necessary to consider the reflection factor of different screens when discussing screen intensities. Nor is it correct to assume that the screen which reflects the highest percentage of light striking it is necessarily the best screen to use, for the manner in which the reflected light is distributed is also a factor which affects the brightness of the picture. For example, it is possible to conceive of a screen which reflects a very large proportion of the light striking it, yet which, due to the fact that it distributes the reflected light far out to the sides, is actually less satisfactory than one which reflects a lower percentage of the light striking it but which confines its reflected light within useful angles.

From the standpoint of their reflection characteristics, screens in common use may be divided into two classes:

Diffuse reflecting screens;
Spread reflecting screens.

Of the first class, white cloth screens and plaster screens are typical. A white cloth screen when clean can be made to reflect as high as 70 to 75% of the light which strikes it; and a plaster screen 80 to 88%. The light is reflected at wide angles, as shown in the slide. Such screens are well adapted to theatres in which the position of the seats with respect to the screen is such that the picture must be viewed at relatively large angles, for no matter from what angle the screen is viewed, the brightness is the same because of the way in which the light is reflected.

Aluminumized screens and ground-mirror screens are examples of the spread reflecting class. A clean aluminumized screen can be designed to reflect about 60 to 65 per cent of the light striking

it and will confine the reflected light within an angle of approximately 30°. Ground-mirror screens when clean can be made to reflect approximately 80 to 90% of the light and confine the light within about 30°. Such screens are well adapted to theatres in which the seats are so arranged that the picture does not have to be viewed at large angles.

Allow me to emphasize the point that the reflection factors I have mentioned assume a clean reflecting surface; a very slight accumulation of dust can reduce the screen brightness very materially. I believe that with a schedule of regular and frequent cleaning, theatre managements can in many cases increase their screen brightness by fully 50% of their present average values if they desire to do so.

Thus, it is seen that the intensity of the beam projected determines only relatively the brightness of the picture.

Uniformity of screen illumination is another factor which must be considered in connection with screen intensities. It is not uncommon to find screens upon which the intensity near the center is several times the intensity near the edges of the picture, or where the intensity on one-half of the screen is much higher than upon the other half. When this condition of non-uniformity obtains, certain portions of the picture are, of course, brighter than others and while the eye cannot readily detect small differences in brightness the fact remains that to say a screen is illuminated to a certain average intensity is not definite when a wide difference exists between minimum, average and maximum intensity values. Good projection requires a screen intensity approaching uniformity, and the nearer the intensities at different points come to being equal the better will be the projection from this standpoint. The uniformity of intensity at different points on the screen is affected by the condenser design, steadiness of the light, and by refinement in focusing adjustment.

Another factor which we must consider is extraneous light. Obviously a higher screen intensity is required in a theatre in which daylight is allowed to enter or where lights are kept burning at all times than in one where all the light comes only from the projection apparatus. The effect of extraneous light is to decrease the contrast between the high lights and the low lights on the screen. If for example the intensity of the beam in a low light of the film is, say, 1/50 of a foot candle at the screen, and in high light the intensity is, say 2 foot-candles, the contrast is 1 to 100. If upon the screen image is now superimposed an intensity of 1/10 of a foot-candle, due to extraneous light, the contrast becomes approximately 1 to 17. From this it is apparent that even a very low intensity of extraneous light calls for considerable increase in screen intensity if good contrast is to be secured. In this connection I may say that the organization with which I am connected has under way at present an investigation of motion picture theatre lighting and will be glad to co-operate

with this Society in determining what constitutes good theatre lighting and in making difinite recommendations for those interested in this subject. There is, I believe, little question that some general illumination is desirable.

Before leaving the subject of contrast, I wish to mention that film producers are endeavoring to a greater and greater extent to provide the proper degree of contrast in their films. More and more care is given to lighting their scenes in such a way that with a projecting beam of normal intensity the proper graduations of light and shade will appear on the screen.

The use of tinted and toned film is becoming more extensive. This tinting and toning serves two purposes—it lends color to the scene, and it reduces the intensity. Usually, the producer has both of these effects in mind. He uses a blue tone, let us say, to portray a moonlight scene. The color gives the observer an impression of moonlight; the producer intends in all probability that the low intensity shall help in furthering this impression. If, then, the operator, seeing that the picture is not perfectly clear, sends a rush of extra current through his carbons, he kills to an extent the impression that the producer hoped to convey. I have talked with producers who considered this natural tendency of the operator to be a matter worthy of no little consideration.

Data which I have obtained on the transmission of samples of tinted film may be of interest.

Absorption of Light by Various Tints of Films.

Film.	Per cent of Absorption.
Blank	9%
Yellow	21%
Light Amber	22%
Heavy Amber	33%
Light Blue	33%
Dark Blue	40%
Green	53%
Purple	62%
Orange	67%
Red	79%

The illumination on the screen with the shutter stationary and no film in the machine has been taken as 100%. The values for the tinted samples are given in percentage of light absorption due to the different tints. The values given in the table represent tests on a single sample of each tint and while these samples are believed to be typical others might of course show somewhat higher or lower values.

In view of the foregoing general discussion you will not be surprised when I say that suitable intensities for motion picture projection range probably from as low as 2.5 foot candles to as high as 30*, depending upon local conditions. I do not think that

*Gage, S. H. & H. P. "Optic Projection," 1914.

2.5 foot candles is sufficient for the projection of a dense film on a dusky muslin screen; neither do I think that an intensity as high as 30 foot candles is desirable for a light film projected on a highly selective or spread reflecting screen. I know of cases where theatre managements have been forced, through the complaints of their patrons, to reduce the intensities they were employing from a value near the upper limit of the range I have given to a considerably lower one. If muslin or plaster screens are used, and these are faithfully kept clean, I believe an intensity of 5 foot candles should be ample for the proper projection of all except very dense films. If an aluminumized or a ground-mirror screen is employed a value of 2½ foot candles should be ample. A great many theatres are projecting pictures with less than 3 foot candles, using a plain screen, while one of the largest and best known theatres is obtaining less than 10 foot candles on a plain screen.† The distinction between dense films and tinted and toned films is of interest. In the former, the density is due to variation in exposure and development and is not as a rule obtained with definite purpose; in the latter, the purpose is to lend color to the picture and to control its brightness. I believe that an intensity of 5 foot candles on any good, clean screen will be sufficient for the projection of any film sent out by a competent producer, and I also believe that no discomfort will be experienced from intensities in the neighborhood of 10 foot candles. In giving these values I presuppose the intensity due to the general illumination of the theatre to be of a very low order and assume the measurements to be made with the shutter open and no film in the machine. As I have previously mentioned, the effect of extraneous light in decreasing the brilliancy of a picture is very marked.

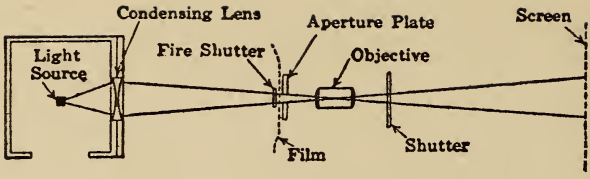
(Mr. Caldwell, by means of demonstration apparatus, showed various photographs and prints illuminated at intensities of 1, 5, and 25 foot candles. The demonstration showed that 1 foot candle was too low an intensity for good vision, that 25 foot candles was so high as to be glaring, and that color distinction and details were largely lost, and that at 5 foot candles the subject appeared to the best advantage.)

You may be interested in a device which has recently been developed which makes it possible to measure screen intensity and screen brightness very quickly and with accuracy.

In this meeting we are interested in projection apparatus only in so far as the component parts of the two systems, arc lamp and incandescent lamp, affect screen intensities. I shall discuss these two systems very briefly from this standpoint.

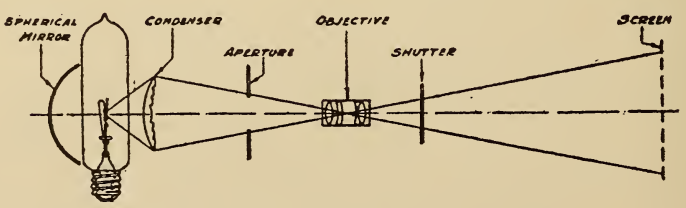
Figure 5 shows the arc lamp system as it is now and as it has been for a number of years. The light intensity at the screen with any system is of course dependent upon the light given off by the source, and with both arc lamp and incandescent lamp systems the light which the source gives off is dependent, but not in equal ratio, upon the current which flows. The intensity

†Optic Projection—J. A. Orange. See Bibliography.



on the screen can, then, be controlled within limits by the current which is forced through the source. The condensers in all arc lamp systems must be located at a considerable distance from the source, chiefly because of the intense heat of the arc, and manufacturing considerations limit the sizes of condensers to the point where, as you will note, the angle or zone subtended by the condenser with respect to the arc is small. With direct-current arcs this is not so great a handicap as with alternating-current arcs, for the direct-current arc throws the greater portion of the light it generates forward. The objectives used with arc lamp equipment are made small in diameter with respect to their focal length in order that irregularities in the arc will not be annoyingly apparent on the screen. There is a possibility of increasing the screen intensity with arc lamp apparatus by increasing the aperture of the objective lens, but under present conditions such an increase would be likely to be obtained at a sacrifice of steadiness in the picture. There seems to be a possibility of increasing the intensity produced by direct-current machines by more careful design of the shutter and possibly by rotating the shutter at higher speeds. It is doubtful if the shutters of alternating-current machines can be much improved because the cooling of the carbons is so rapid that a stroboscopic effect is likely to be encountered. This effect is, of course, marked at present where 25-cycle current must be used.

OPTICAL SYSTEM USING MAZDA C LAMP
FOR
MOTION PICTURE PROJECTION



You will note that with the incandescent lamp system, Fig. 6, a mirror can be used to redirect into useful directions the light which the lamp gives off in directions away from the condenser. The use of this mirror increases the illumination on the screen by approximately 75%. The lamp is so designed that relatively little light is thrown off to the sides, that is, a relatively large part of the light either strikes the condenser directly or indirectly

by reflection from the mirror. The fact that the light source is confined within a bulb eliminates danger of cracking the condenser; hence a short-focus condenser which subtends a large angle can be utilized. Through the design of a special prismatic condenser, Fig. 7, the necessity for a thick and heavy lens with accompanying aberration is obviated. The fact that the light source is absolutely steady and without noticeable flicker, even on 25-cycle current, permits the use of a wide aperture objective lens with an accompanying good utilization of light. Shutters can be designed to operate very effectually with incandescent lamp equipment because of the fact that the filament, being heavy, does not get a chance to cool between current reversals. When arc machines are being adapted to the incandescent lamp, it is of advantage to bear the point in mind that the shutter can usually be improved. It is due solely to the better utilization of light that the incandescent lamp, a source of lower brilliancy and far less energetic consumption than the arc, can be used to project satisfactory motion pictures.

For many years the arc lamp has been practically the only light source used in motion-picture projection work and higher and higher amperages have been employed as the size of theatres has increased and as competition between theatres has become keener. It appears that a reaction from the very high values may be logically expected, for a brilliant picture loses its attractiveness when discomfort and eye strain from glare is experienced. A bright screen viewed against a dark background produces an effect similar to that produced by a bright street light viewed against its background. In the first case the effect is less marked and may not be attributed to contrast in brightness, and for this reason is probably more serious than as if the trouble were recognized at once and corrected. Flicker and arc travel are also more pronounced at high intensities than at low ones, yet while pictures projected by incandescent lamp apparatus are free from these objectionable characteristics too high an intensity with such equipment is nevertheless quite capable of producing glare. We may, therefore, I believe, expect to see the higher intensities gradually be abandoned in favor of intensities of the lower order.

In closing, the subject of projection as treated by others should be of interest to us all. A few of the papers on this subject are:

THE PROJECTION LANTERN, by J. B. Taylor, page 414, No. 3, Vol. XI, I. E. S. Proceeding.

OPTIC PROJECTION, by J. A. Orange, page 768, No. 8, Vol. XI, I. E. S. Proceeding.

OPTIC PROJECTION, by S. P. & H. P. Gage, published by Comstock Pub. Co., Ithaca, N. Y.

PROJECTION ENGINEERING, by R. B. Chillas, Jr., page 1097, No. 9, Vol. XI, I. E. S. Proceeding.

LIGHT PROJECTION—ITS APPLICATION, by E. J. Edwards and H. H. Magdsick, a lecture delivered at the University of Pennsylvania through the I. E. S. in September, 1916, I. E. S. Proceeding.

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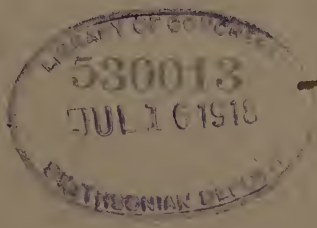

MEETING OF APRIL 8-9, 1918

ROCHESTER

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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers stands for unselfish service to the Industry. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein, and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts, or who is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least one member in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee for all members shall be twenty-five dollars ($25.00). The annual dues shall be ten dollars ($10.00), payable in advance before the annual meeting (October) of each year. That is, the total fee for the first year, which includes the entrance fees and first annual dues, is $35.00 for all members.

PRESIDENT'S ADDRESS

Gentlemen:

The organization of our Society had four objects in view, three of which are mentioned in the by-laws because they would never be so completely attained that further progress would be impossible. The fourth object was inferred only, because one day we will have accomplished this object fully.

I refer to that day, greatly to be desired, when our industry will be respected. At this time our industry is known as "the movies," a term of derision, though the term is so expressive that eventually it will be accepted in our language and appear in standard dictionaries, but at present a term of mild contempt, nevertheless.

There is today no other industry at once both so big and so defenceless. The latter accounts for our detractors' distortion of facts.

First, the motion picture industry is openly charged with a deliberate intent to pander to the lowest moral taste; and so we have censorship boards.

Now, if this opprobrium is deserved, steps should be taken to correct this condition. If it is not deserved, an unobtrusive, but persistent campaign to change public opinion should be inaugurated.

Second, it is alleged that our industry is extra hazardous, and so we are denied privileges accorded other industries far more hazardous.

Believing these conditions might be improved I have been working for some months, single-handed, and I have made some progress, arguing on the hypothesis that there are but two causes of film fires, namely, (1) the machine and (2) the operator. Any effort to reduce the fire hazard from either cause is worth while, it seems to me.

One result already achieved is a specification prepared in collaboration with an officer of the National Board of Fire Underwriters for a projector with so high a safety factor that it may be used without a booth, for should this be adopted by the Board of Fire Underwriters it will prove a wonderful boon to educational institutions; to industrial organizations; in rural development, and in hundreds of other avenues of usefulness.

The motion picture does not deserve the bad name for hazard which it now has. I feel that projecting machines can be made which will not cause film fires under any circumstances. Many fire and insurance officials concede that this is possible, but contend that the film is unsafe. But is it? The express companies and parcel-post carry about five hundred tons of it daily, and safely.

I have been claiming for some time that the other element, the concealing booth, is the cause of most film fires, and to authoritatively discover the accuracy of this assumption, I asked the National Fire Prevention Association for a report on the subject. This data was graciously furnished and was afterward made the subject of official report, and this will be found elsewhere in the proceedings of this meeting. Needless to say I was gratified to learn that not a single film fire was recorded as occurring when the exhibition was given without

a concealing booth; and also that more than sixty per cent of the common causes of booth fires were such things as would prevail only where the operator is concealed, that is, smoking, carelessness, a dirty booth, and failure to immediately return the film to its metal container. Smoking alone made up more than fifty per cent of the common causes of film fires.

I think, therefore, that our contention has been substantiated, namely, that a machine can be made which is safe within itself, and that film is not as hazardous as the unusually stringent regulations would seem to indicate. Both of which will greatly enlarge the usefulness of motion pictures in the immense field outside of theatres.

It is suggested, therefore, that, at this meeting, we put into motion two activities, *i. e.*, (1) efforts looking to the approval of a safe machine for use outside of theatres, and (2) a publicity campaign for better regard for our industry by the public generally. The first will come up under the head of new business at this session, doubtless; and as for the latter I suggest that the continuation of such publicity be so directed as will make for a higher regard for our industry, and, so far as practicable, that it be made in the name, and in such a way as will maintain the dignity and unselfish motives, of our Society.

Already much has been accomplished, and each of our meetings is better than the preceding one. A steady continuation of our splendid work will make the Society of Motion Picture Engineers a great power for advancement.

Standardization of Exposure

John W. Allison

Standardization of an industry should begin at the beginning, and as the producers of motion picture film have a standardized product to start with, *i. e.*, the film, the first thing for the producer to standardize is the exposure, and this can only be done by standardizing the conditions under which the film is exposed. Of course, I refer to work in the studio.

Messrs. Hurter & Driffield, of England, whose research work in the photographic field is recognized as standard throughout the world, put great stress on the necessity of securing a technically perfect negative. Let me quote a few words from their little book on "Photo-Chemical Investigations and Methods of Speed Determination":—

> "While we quite realize that the artist will always produce the best *picture*, we contend that the scientist will produce the best *negative*. The photographer, therefore, who combines scientific method with artistic skill is in the best possible position to produce good work.
>
> "The truthful representation of light and shade involves the production of a technically perfect negative, *i. e.*, one in which the opacities of its gradations are proportional to the light reflected by those parts of the original object which they represent. Our investigations show that such a relationship does exist, but only when a plate has received what we term a *correct exposure*.
>
> "While many photographers attach very little importance to accuracy in exposure, and maintain that errors may be readily corrected by suitable modifications in the composition of the developer, we have always strongly insisted that a correct exposure is an essential foundation if we aim to procure a technically perfect negative. It must be clearly understood, however, that, by a correct exposure we do not imply that there is necessarily one exposure, and one only, which will yield a negative answering to our definition. Fortunately, most plates admit of some latitude in this respect.
>
> "Our contention is that the latent image, false in its gradations, cannot, by modifications in the constitutions of the developer, be made to yield a visible image true in its gradations. The practice of photography, by methods of scientific predetermination, imperatively demands a correct exposure as a fundamental condition."

The standardization of the exposure so that at all times every foot of film exposed in the studio will be uniform in density will do away with the necessity of variations of timing on the printer, and eliminate the uncertainty of the finished result, and one can predetermine the screen results when toning or dying is resorted to.

I have been working on an indirect system of studio lighting to standardize the exposure, in which the volume of indirect light is

governed by the cubical area to be lighted, and in addition to which the light effects are secured by the use of a few diffused direct light units. In this way the photographer can exercise his artistic ability with the assurance of a perfectly exposed negative resulting. Of course, studio conditions will have to be somewhat changed from the present methods of working, but the certainty of the results will warrant the expense.

To my mind the use of direct light in the studio is a great mistake. Ninety percent of the time we spend in indirect, or reflected light. Such being the case, why should we not make our photographs under the conditions under which we normally live?

The Eskimo is a specimen of a human being who spends most of his life under direct light. Now who wants to look like an Eskimo?

By careful use of the exposure meter, in outdoor work, the exterior exposures can be standardized to balance with the studio work, so that the same treatment will do for both.

Optical Requirements of Motion Picture Projection Objectives

By Alfred S. Cory

In the motion picture industry, as in every other modern industry, the trend in mechanical and technical matters is always towards increased efficiency combined with improvement in quality, and on the present occasion I bring to your notice the results of a comparative study of motion picture projection objectives from the standpoint of their defining properties and the efficiency with which they utilize the light source of the motion picture projector.

As the analogy between the production of an image, or picture, in the photographic camera, and the reproduction of an enlarged screen picture by the motion picture projecting machine, is a very close one (*the two processes being in fact merely the inverse of one another*) we are provided with a ready means of studying and comparing the capabilities of projection objectives, by subjecting them to the same considerations that are applied to the investigation of the properties of photographic objectives, but before we proceed there is a difference which should be pointed out between the character of the work which is to be accomplished by the photographic objective and the projection objective respectively.

In the case of the photographic objective the angular field, or field of view, required to be covered is seldom less than 30 degrees, which is considered a very narrow field in photography, but in the case of motion picture projection the field which comes into play is only about 15 degrees in angular extent, (*for an objective of 4″ E. F.*) and is even less in the case of long focus lenses. Were it not for these extremely moderate requirements, as regards the angular extent of the field of view, the effect of the aberrations of the customary projection objective would be much more apparent in the screen reproduction.

On the score of aperture, or intensity, however, the requirements of photographic objectives and projection objectives are identical, for in both cases the greatest aperture is essential which is compatible with freedom from a noticeable amount of aberration in the projected pictures. Thus the bundles of rays transmitted by a projection objective are of large angular section, as in the case of the photographic objective, but the most extreme rays from the film picture to be projected have very slight inclinations to the axis of the objective when compared with the obliquities met with in photography.

As is well known, the images formed by lenses are affected, as regards sharpness or quality of definition, and as regards the accuracy with which they reproduce the projected object, by a series of aberrations, the most representative aberrations, from the viewpoint of the optical constructor being:

(1) Chromatic aberration (*due to the composite nature of white light*).

(2) Axial spherical aberration.

(3) Spherical aberration for points outside the axis.
(4) Astigmatism.
(5) Curvature of the image field (*invariably associated with 4*).
(6) Distortion.

A brief outline of the cause of these various aberrations, their effect on the projected image, and the requirements for their elimination, or correction, will be given, and a comparison between the customary projection objective, and some objectives of improved construction, will be made on the basis of the extent to which the various aberrations have been eliminated in the several types of objective considered.

To save time in reviewing the effects of the several aberrations upon the definition of the projected picture, we will assume in the first place, that any objective which is worthy of investigation has been chromatically corrected for at least two spectral colors, and has also been spherically corrected for rays parallel to the axis, *i. e.*, is so corrected that the axial ray and the edge ray after refraction by the objective cut the axis at the same point, which point of intersection is known as the focal point of the objective in question.

The fact that an objective is spherically corrected for the center of the field does not, however, assure the sharp reproduction, in the image, of portions of the object which are situated outside the axis, because the zones of the objective between the axis and the margin exert their influence on oblique pencils in a manner which is quite fatal to crispness in the image, and this effect is number 3 on the list of aberrations, being known as coma. Spherical aberration of the oblique pencils of rays gives a fuzzy appearance to the image, the reason for this being that the various zones of the objective have not the same magnifying power, due to the unsymmetrical refraction of the rays in the meridian sections of oblique pencils. In first approximation Abbe showed that for the elimination of coma the ratio of the sines of the angles made with the axis by any and every ray proceeding from the axial object point and refracted to its image point must be constant, or in other words

$$\frac{\sin\ u'}{\sin\ u} = \text{constant}$$

where u is the angle which the incident ray makes with the axis and u' is the angle which the refracted ray makes with the axis. This ratio must also be equal to the linear magnification. In the case of parallel incident rays the relationship

$$\frac{h}{\sin\ u'} \text{ must be constant}$$

where h is the height of incidence of the ray considered, measured from the axis. This ratio must be equal to the equivalent focal length of the objective and the difference between the value of $h/\sin\ u'$ and the equivalent focal length, F, for any zone of a given objective repre-

sents the deviation from the sine condition for that zone of the objective, and if the sine condition is approximately fulfilled in an objective the values of

$$\frac{h}{\sin u'} - F$$

for the various zones will be nearly equal to the outstanding spherical aberration for the same zones as compared to the focus of the axial ray. Zonal variations of the equivalent focal length are eliminated over a narrow field, *i. e.*, up to 7 degrees from the axis (*15° field of view*) when the sine condition is fulfilled as a first approximation, but in the case of wider fields a special correction for coma may be necessary, which is, however, outside the scope of the present considerations.

The commercial varieties of projection objective are made along lines similar to those proposed by Petzval in 1840, and the deviations in present day manufacture from the original Petzval Portrait objective are so slight that the projection objectives now generally in use are similar in their characteristics to the original Petzval lens. The Petzval objective has always been celebrated for its critical definition in the center of the field, which compares very favorably with the most modern objectives over a restricted area in the vicinity of the axis.

At a distance of 12 mm. from the axis (*corresponding to one-half the width of a film image*) the deviation from fulfillment of the sine condition commences to assume such proportions, however, that there appears to be room for improvement through the use of some other type of objective wherein the sine law is fulfilled for a greater distance away from the axis, because the edges of the motion picture image are outside of the region over which this important correction is operative in the case of the Petzval objective. By the use of certain types of photographic anastigmats as projection objectives a field much in excess of the diagonal of a film image may be secured which is free from coma, and as these modern types of objectives appear to possess numerous other advantages they will be considered more extensively in the course of my remarks.

A further deterioration in the definition of the projected motion picture image is the result of astigmatism and curvature of field, two associated aberrations which appear as numbers 4 and 5 on our list.

A description of the effects of astigmatism and curvature of field upon the projected image will show the importance of correcting the projection objective for these aberrations, so we will dwell briefly upon the matter, reference being had to Fig. 1.

In the diagram a pencil of light rays, supposed to be of very narrow cross-section, is incident obliquely upon a positive lens. The cause of astigmatism is found in the fact that a different contour of lens surface is presented to sections of the incident oblique pencil which are 90° apart, and the refracting effect of the lens is thus different for different portions of the incident pencil.

The section of the oblique pencil of rays which contains both the axis of the pencil and the axis of the lens is known as a primary or meridian section, and is denoted by A B in the diagram, while the sec-

tion at right angles to A B *through the oblique pencil* is known as the secondary or equatorial section C D of the same oblique pencil. Proceeding now to follow the course of the rays after the oblique pencil has been refracted by the lens, we note that the rays of the equatorial section C D come to a focus at I in the form of a line, which radiates from the axis, while the rays of the meridian section A B, come to a focus further back at II as a horizontal line which is at right angles to the radial line at I, or, more strictly, it is tangential with respect to the circular image field. At the position I, therefore, we have vertical, or radial elements of the object in focus and horizontal details blurred beyond recognition, while at II we have horizontal, or tangential, object elements sharply delineated but the vertical elements hopelessly out of focus. Somewhere between I and II is a position of minimum indistinctness which is known as the circle of least confusion, and would represent the best marginal definition attainable with the uncorrected lens.

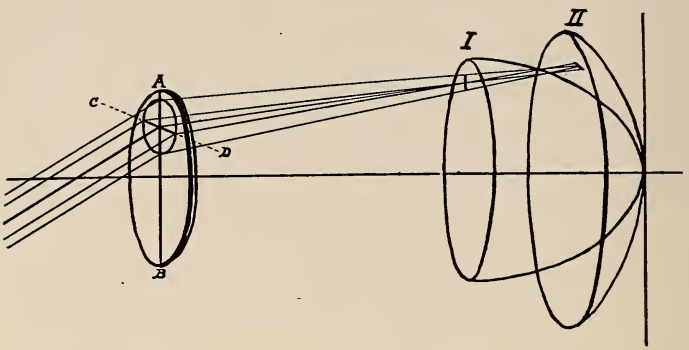


FIG. 1

The converging of oblique pencils to two focal-lines is not the only consequence of oblique refraction, however, for the respective radial and tangential lines are located on two very curved surfaces, as the diagram shows, and these curved image-surfaces only coincide at the axis of the lens. The difference between the curvatures of the I and II astigmatic image-surfaces is known as the astigmatic difference, which increases with increasing angles of obliquity of the incident rays. This deformation of the image-surfaces, *i. e.*, their departure from the flatness of an ideal focal-plane is known as curvature of the image-field, and it is found desirable when correcting an objective for the removal of astigmatism to abolish the astigmatism and the curvature of the field simultaneously.

By suitable design and choice of the glasses, an objective may be made which brings the I and II image-surfaces into contact, whereupon the lens is free from astigmatism and renders a sharp image, but this single anastigmatic image-field may still be a very considerably curved surface. It is therefore the aim of the optical computer to render the field flat and perpendicular to the axis at the theoretical focal-plane simultaneously with the bringing together of the I and II image

surfaces. This is accomplished when the Coddington-Petzval condition is fulfilled, which requires that

$$\sum \frac{1}{r} \Delta \left(\frac{1}{n} \right) = 0$$

i. e., the sum of the products obtained by multiplying the curvature of each refracting surface by the difference of the reciprocals of the refractive indices of the media bounding that surface must be zero. When this equation does not equal zero its value indicates the curvature of the image-field at its vertex, or, in other words, at the axial focal point.

NOTE—*The Coddington-Petzval condition is only operative when the astigmatism has first been abolished, that is when*

$$\sum \Delta \left(\delta \right) = 0$$

i. e., the sum of the differences in the diameters of the circles of confusion (*corresponding to an extra-axial point of the object*) resulting from the refractions at each of the surfaces of the system equals zero.

In the case of some modern photographic objectives the astigmatism and curvature have been eliminated over a very wide field of view, although in anastigmatic corrections, as well as in ordinary spherical corrections, there remain, in the case of most objectives, small outstanding zones where the I and II image-surfaces have not been brought completely into contact, or where the field is not perfectly flat and at right angles to the axis of the objective.

As a concrete instance of the existence of these astigmatic deviations, and departure from strict planeity of the image-field, the Petzval type of projection objective shows a noticeable degree of astigmatism, or curvature of the field, or both, at 5° from the axis (*corresponding to a field of view of 10°*) while at 7° from the axis (*corresponding, roughly, to a 15° field of view*) the astigmatism, or the curvature, or sometimes both, are of quite appreciable extent. To those who have never experimented with lenses from the constructional point of view it will be of interest to state that by separating the front and rear components of a Petzval type objective the flatness of the image-field is improved, but at the same time the I and II image-surfaces tend to separate from one another more and more as the lens components are spaced increasingly farther apart, so that flatness of field is attained at the expense of increased astigmatism when the correction depends solely upon the empirical principle of separation. On the other hand a very close approximation to complete coincidence of the I and II image-surfaces may be brought about by bringing the components of the Petzval objective close together, thus eliminating astigmatism almost entirely, but in this case a very much curved field results, which is equally as objectionable as the presence of astigmatism both to the photographer and the optical projectionist.

As it is therefore to be seen that the Petzval objective possesses neither complete freedom from astigmatism, nor a perfectly flat field of sufficient angular extent to permit of perfect definition over the entire extent of the projected motion picture image, it appears that in order to achieve the utmost in sharpness in cinematographic projection some of the modern types of highly corrected objectives could be utilized to advantage in this class of work. Projection objectives of the photographic anastigmat type have been used n England and on the continent for some years past with great success, and I need not therefore apologize for directing the attention of the Society, and the industry at large, to the improved results which may be secured by the use of projection objectives of modern design.

The number of different types of highly corrected or so-called anastigmat photographic objectives now on the market is very large, but only a few types are eminently suitable for projection purposes, the principal requirements of a projection objective, in addition to the abolition of the previously mentioned aberrations, being:

(1) Large effective aperture.
(2) Minimum of (*glass-air*) reflecting surfaces.
(3) Minimum of cemented surfaces.
(4) Compactness of construction, *i. e.*, short distance between the front and rear components.

When these requirements and also the corrections for flatness of field and freedom from astigmatism are taken into consideration, the selection narrows down considerably, and of the many modern photographic objectives available I direct your attention to only two specific types, these being the Cooke objective series II *f* 4.5, the Zeiss I C Tessar *f* 3.5.

For the purposes of cinematographic projection both the Cooke Series II and the Zeiss I C Tessar can be made with effective apertures of *f* 4.5 or even *f* 3.5, and beyond an effective aperture of *f* 3.5 it seems extremely inadvisable to go, because with further increase in the effective aperture the aberrations inherent in all objectives can no longer be suppressed to the degree at which they are invisible in the projected results.

The influence of residual aberration upon the screen images produced by objectives of extremely large effective apertures may be readily demonstrated by projecting a test slide, or film, containing printing or any other fine contrasty pattern. It will then be found that the blackness of the letters, or pattern, is much more pronounced when projection is accomplished with an objective of moderate aperture than is the case when one of extreme aperture is employed, because the residual comatic and astigmatic errors which are inseparable from objectives of large aperture tend to gray the projected image, thus robbing it of a certain degree of snappiness or proper contrast.

The Cooke lens has six glass-air surfaces, as has also the Tessar, both being identical with the Petzval objective in this respect. In view of the light loss by reflection at glass-air surfaces an objective

with only four open surfaces would be desirable for projection purposes, but the production of such an objective of sufficiently large aperture does not seem compatible with the corrections required, although some of the objectives designed by Hugh L. Aldis of Birmingham, England, are suggestive efforts along this line.

In respect of cemented surfaces, the Cooke lens has none, being ideal in this respect for projection with high power illuminants which generate considerable heat; the Tessar has one cemented surface which would doubtless hold up well as no trouble is ever experienced with the cemented surface in the Petzval type objectives now commonly in use. The Cooke and the Tessar objectives are both of compact construction and are therefore superior in this respect to the Petzval objective, an advantage which will be again referred to.

The corrections for coma, astigmatism and curvature of field are carried out to a high degree in these two modern types of objectives; there being no noticeable departure from the sine condition, and the field being almost perfectly flat and free from any noticeable trace of astigmatism for upwards of 10° away from the axis, thus allowing the projection of a sharp stigmatic image of 20° or more in angular extent.

Distortion, the seventh aberration on our list, has been deferred until the last because under the conditions generally met with at present wherever motion pictures are projected, the elimination of distortion would appear to be an almost needless refinement in a projection objective, although, of course, this correction should be carried out to the utmost extent possible in a large aperture objective, and is carried out by all reputable opticians.

Distortion in a photographic or a projection objective may be briefly described as an increasing or a decreasing scale of reproduction from the center to the edges of the images produced by objectives of either simple or compound type, and it results from the refractive effect on rays incident at increasing angles with respect to the axis being such as to cause the angles made with the axis by the chief-rays after refraction to differ from the angles made by the same rays, with respect to the axis, before refraction.

(NOTE—*A chief-ray is the representative ray of a pencil; it is the ray which passes through the center of the diaphragm of an objective and therefore through the center of the entrance-and exit-pupils.*)

In order that an objective may be free from distortion, and yield an orthoscopic, or rectilinear, representation of the object projected, Airy's condition must be fulfilled, which requires that the ratio of the tangents of the angles made with the axis by corresponding chief-rays on the object side and on the image side of the objective must be constant, or

$$\frac{y}{y'} = \frac{a \tan w}{a' \tan w'} = N$$

where y and y' represent the size of the object and the image respectively; a and a' are the distances of the entrance- and exit-pupils from the plane focussed for (*the film image in motion picture projection*) and the image plane (*or lantern screen*); w and w' are the angles made with

the axis by corresponding chief-rays on the object side and the image side of the objective, and N is the reduction factor.

The "tangent condition," as it is generally known, is precisely fulfilled *in the case of symmetrical objectives*, for one pair of conjugate positions of the object and image, *i. e.*, in the case of unit magnification, and freedom from distortion may be realized for certain other positions of the object by also correcting a symmetrical objective spherically with respect to the position of the diaphragm and its images—the entrance- and exit-pupils (*Bow-Sutton condition.*)

Orthoscopy is not completely realized for any distance of the object by unsymmetrical objectives, however, and with respect to correction for distortion most of the modern anastigmatic objectives show about the same amount of positive distortion as the Petzval type projection objective. This is not a matter of such moment in every-day motion picture projection as it is in photographic reproduction work, for in less than one theatre out of every hundred is the center of the screen co-axial with the projector optical system, or the entire screen perfectly perpendicular to the axis of projection. Inasmuch as operators, theatre managers and architects have failed in the majority of cases to provide for an orthoscopic representation on the projection screen, it can be claimed that the distortion errors due to conditions prevailing in the majority of theatres far transcend the amount of distortion to be found in the images produced by any of the modern types of objectives, when they are used for projecting upon a screen placed truly perpendicular to the axis of projection.

(Note—*For convenience I have created the expression "axis of projection" which is defined as the prolongation of the axis of the projector optical system (assumed to be in perfect alignment) as a straight line to the projection screen. I suggest that this definition be adopted by the Society and included in the Society's list of Motion Picture nomenclature*).

As all of the modern anastigmatic objectives having a large aperture are of unsymmetrical construction, they exhibit about the same amount of distortion as to Petzval objective at angles up to 10° from the axis, but there is one notable exception to this statement—the objective in question being the I C Zeiss Tessar of *f* 3.5 aperture ratio. In this objective, which has previously been recommended as eminently suitable for projecting purposes, distortion has been reduced to an almost negligible quantity at 10° away from the axis, which is quite remarkable considering the large aperture. I have not been able to examine one of the recent Cooke anastigmatic projection objectives which are said to work at *f* 2. and I cannot therefore report upon it with respect to distortion, but the Cooke objectives of smaller effective aperture are very well freed from distortion, thus indicating the possibilities of securing a good correction in this respect for the Cooke objectives of larger aperture.

A final advantage which can be claimed for the modern types of photographic objectives, when used in motion picture projection, is their compact construction, which permits a very efficient utilization of the available light source.

An elementary investigation will show that in the case of the Petzval type of projection objective generally in use, a considerable amount of the light proceeding from the margins of the machine aperture (*or film picture*) is intercepted within the mounting or tube of the objective, and can not therefore reach the projection screen. By the use, however, of the types of objectives recommended in this paper, a considerable amount of light which fails to reach the projection screen, due to the vignetting action of the customary objective, may be fully availed of, because anastigmatic objectives, such as those used in photography, are characterized by a much shorter distance between their front and rear components than is the case with the Petzval objective. In virtue of this fact, a modern form of objective of compact construction can transmit as much light as a larger aperture objective of the same focal length but with greater separation between the components, and when we consider that the visible effects of aberration increase with increase in the relative aperture, it is clear that improvement in motion picture screen delineations must be reached through the compact and efficiently corrected modern anastigmat objectives of similar type to those recommended.

My thanks are due to Dr. Hermann Kellner for having kindly gone over this paper prior to its presentation before the Society, and also for some demonstrations relating to the subject made at the Bausch & Lomb Optical Works.

Artificial Light in the Motion Picture Studio

By Max Mayer

When we turn back to the early pages of motion picture history, we come to the time when our pioneer producers began to look upon picture-making as an everyday and allday task, rather than an occasional diversion.

It was then that the pranks of old Sol began to be felt more keenly than when it was practical to wait for the clouds to roll by.

Confronted by a rapidly growing demand, the producer readily saw two alternatives; the land of eternal sunshine or artificial light, so he promptly reached out for both.

Artificial light was being extensively used both for still photography and in the Graphic Arts, and fairly suitable units were therefore available for cinematography.

At the time the main aim was to get lamps enough to light the sets, and somehow they never seemed able to get quite enough, no matter how many were used.

This condition prevailed, until the more recently developed tendency, to produce pleasing and natural light effects, superseded the earlier method of flooding the scenes with light from every available point.

Thus the lights were used virtually to produce shadows and contrasts, and far better results were attained with less light; in fact, many effects difficult and impracticable to obtain by sunlight are more readily achieved in a darkened studio with suitable electrical equipment.

This subject as a whole is wide in scope, and the writer dares herein to attempt nothing more than a superficial discussion thereof.

To this end three general classifications will aid in dealing with the topic:

(1) The nature of the light sources;

(2) The manner of their application;

(3) The manner of installation of equipment.

Under the first heading, consideration should be given to the color composition of the light, the degree of concentration of the light source itself, the nature and value of reflectors and auxiliary reflecting surfaces—and the nature and value of diffusing screens.

1 Color Composition of Light

The color sensitiveness of the photographic emulsion, of course, determines the usefulness of the spectrum range of the light source.

The modern film used in the motion picture camera is sensitive over a considerable portion of the sun spectrum and consequently sunlight will record on the film more speedily and correctly than a light source in which one or more colors to which the emulsion is sensitive, are absent or weak.

Artificial light sources which do not cover the full sensitive range of the emulsion can not give maximum results, unless used in conjunction with other light sources which supply that deficiency.

The mercury vapor lamp, though completely lacking in some colors, is nevertheless a valuable unit for this work, owing to its wonderful light diffusion and is very extensively used in conjunction with powerful arc lamps employing "white flame" carbons.

There is a great deal of valuable information to be gathered on photographic color values, and it is to be hoped that the S. M. P. E. may be favored at an early date with a paper on this topic by some of the many brilliant men of the Eastman laboratories.

CONCENTRATION OF LIGHT SOURCE

If a light source be considered as a point, the light would emanate therefrom equally in all directions, and the rays would all form diverging angles. Such a point of light would be the extreme concentrated light source. Consider now a plane surface—a square, for example, formed by minute light sources, whose collective intensity is equal to an assumed intensity of the aforementioned concentrated light source.

Such a luminous surface might be considered an ideal diffused light source. At a given distance, this diffused light source, as compared with the concentrated light source, would evenly illuminate a greater area at a proportionately lesser intensity.

In the language of the studio, the light from the luminous surface would not carry so far as the concentrated light, but would be more scattered or diffused, producing an effect often very much desired in photography.

If the light, from a concentrated light source, such as a flame arc, for example, is passed through a piece of roughed glass or similar medium, a diffusing or scattering effect may be obtained, involving, of course, a loss proportionate to the absorption of the medium. Thus it is practicable to obtain most any degree of diffusion from a concentrated light source; but the scattered light from a luminous surface cannot be concentrated.

Another form of concentrated light, now extensively used as an auxiliary, is the projected beam or spot light. This is usually in the form of a high-powered hand-feed arc, (70 to 100 amp. and often more) with a single plano-convex condenser. The principal fault with this form of unit is its low efficiency, probably mostly due to the filtering effect of the thick condenser glass. However, the striking effects obtained by this means will easily offset this inefficiency.

It might be interesting and instructive to note the effect obtainable through a condenser lens of quartz as compared with the ordinary glass condenser.

REFLECTORS AND REFLECTING SURFACES

The uses of reflectors on various types of lamps are to re-direct the rays (which would otherwise go in useless directions) toward the object to be illuminated, and further to obtain by their use various degrees of concentration, according to the shape of the reflectors. While

surface mirrors would probably represent the ideal reflecting surface, their use would hardly be practicable owing to the difficulty of keeping large numbers of them clean under the studio conditions.

Either a mat white surface of slightly bluish tint or a mat aluminum surface are found quite satisfactory, particularly for the flame arcs, as the white ash deposit from the carbons does not materially alter the reflective value of the surface; thereby keeping the light source practically as constant as the lamp itself. With mirror-surfaced reflectors, this ash deposit would gradually decrease the light strength, and cleaning would suddenly restore it to full brilliancy. It is plain that this would be a disturbing factor to the camera man.

The value of reflecting panels has long been recognized by portrait photographers. Cinematographers also use them when working with sunlight; but they have been slow to adopt them in conjunction with artificial light. These auxiliary reflectors are, however, none the less valuable for this purpose. Mat white or aluminum painted surfaces have been the customary practice, but a much more effective reflecting surface may be made by stretching white oil cloth on a frame, treating the smooth surface with sizing and coating it with leaf aluminum, in a manner similar to that employed in show-window lettering. Such reflectors will do wonders in bringing out detail in shadows and in toning down hard contrasts, and will actually reduce the number of lamps required.

DIFFUSING SCREENS

Much experimenting has been done with different materials for diffusing the light and unfortunately the ones which absorb the least light are also least capable of resisting the hard usage in the studio. Very thin glass roughed, finely ribbed, or of otherwise irregular surface, while highly efficient, is out of the question owing to its fragility. Draughtsman's tracing linen is a good and fairly efficient diffuser, but must be kept at a considerable distance from the heat of the arcs to prevent burning or scorching. As this increase in distance from the light source increases the degree of diffusion and necessitates a larger diffusing area, this material is only practicable where extreme diffusion is desired, and therefore, for contrasty effects it is better to use a smaller surface closer to the light source. Strips of glass, about one-eighth inch in thickness, roughed, ribbed or prismatic, give fair results, and one form of diffuser made of woven spun glass mounted in frames does quite as well and overcomes the mechanical weakness of the fragile glass strips.

2 Arrangement of Light Sources

Almost everyone directly connected with the art and technique of motion picture production has some pet ideas of his own on lighting and many who exploit their ideas in their daily work are getting commendable and pleasing effects; some as the result of forethought in arranging the light, and others by mere accident.

However, the arrangement of the lights and reflectors is as much a matter of art as of science, and it is futile to attempt to make fixed rules along these lines. In fact, such a step would meet with just re-

sentment; for many of the beautiful light effects we see on the screen are the result of unique and original ideas of artistic minds.

In photographing the modern film play, no fixed set of light arrangement is practical, as the lights must be placed for each scene to suit the effect desired.

For the general illumination of a scene, the aim should be to attain inconspicuous soft lighting, showing the entire scene and figures therein well modelled and in good detail. In this case, well diffused light and plenty of it is necessary, for if the lamps be placed close to the camera line, the difference in intensity from the light to the opposite side of the set would be extreme, while if the lamps are placed at considerable distance from the line this difference in intensity between opposite sides of the set would be greatly diminished, but the amount of light required would be proportionately greater. With sunlight this disturbing condition does not enter, for with the light source ninety odd millions of miles away, the difference in distance from the sun between opposite sides of the set would make a ridiculously trifling computation. But in the above condition, the intensity diminishing by inverse squares of the distance must be considered, and practice shows that the lamps should be kept away from the camera line by at least one-quarter the distance across the set at that point. However, this is seldom carried out and the camera man is generally blamed for unsatisfactory results, while the real fault lies in the fact that sets are usually so crowded together in the studios, that there is no room left for lamps except close to the camera line. To offset this condition, an excessive amount of top light is then crowded over to the dark side of the set, and while this may help in a way, the effect obtained is unnatural and seldom pleasing.

On the whole it is best to confine general lighting to small sets or to avoid it altogether on interiors. If we study the sunlight illumination of the average room, we find that we must resort to effects in order to simulate the natural conditions and shadows.

Back lighting is a splendid way of obtaining pleasing and natural results. This is effected by placing the lights well back and directing them toward, but not at the camera, masking the direct rays at the lamps and preferably using a shielding tube with perfectly dull black interior, over the lens barrel, to prevent halation.

Thus the figures and objects in the set will be silhouetted and by the proper front arrangement of reflecting surfaces and well diffused lights at a fair distance, the features and details may be perfectly modelled in shadow, with pleasing highlight relief effected by the rear lights. Of course, good judgment and practice are essential to carry this out effectively.

This arrangement adapts itself better for an added light effect from a window, lamp, fireplace, or the like, than a general illumination, as the figures being detailed in shadow will light up readily by contrast when they enter within the range of the added light; while in a set fully lighted, such an added effect requires an extremely powerful light source to further illuminate the already well-lighted features, and the effect is usually spoiled by the bleaching out of detail.

Back light may be effected either by top lamps or floor stands or by both. When top light is used, the lamps are best fitted with diagonal reflectors and hung near the back of the set. Care must be used to hide the shadow line cast by the rear of reflector. The lamps should be so hung that this shadow line comes just at junction of floor and rear wall. In small sets an aluminum reflecting panel suspended in front of camera just clear of the lens angle and another on the floor in front of the camera, both carefully set at proper angles, will supply sufficient front light to outline features and other details in shadow, and a diffused floor light on one side, some distance back of camera, will mould these details most pleasingly.

Such an arrangement, used effectively in one of the studios, consisted of six double arc top lights, one 8 tube mercury vapor bank, a six- by eight-foot hanging reflector, and a four- by eight-foot floor reflector.

This outfit, with no other light was used repeatedly in sets of twenty to twenty-five foot depth with splendid results.

This is just one illustration to show how a pleasing effect may be obtained with a small number of lights.

An almost endless variety of light arrangement could be described here; but that would stretch this already lengthy paper into a probably wearisome volume.

3 Installation of Equipment

First of all let us deal with the manner of installing the overhead lights, as this seems to be a source of worry to everyone equipping an artificially lighted studio.

An overhead carriage or trolley system which facilitates the free and easy movement of the individual lamps or banks, both longitudinally and transversally through the studio, and which provides for the convenient raising and lowering of the lamps; that is the problem usually handed to the architect, or contractor.

After ascertaining the weight of the lamps, the weight of the structure required to move and support them grouped in most any position over an area—usually of 5,000 sq. ft. or more—he finds this a weighty problem in more than one sense; often requiring reinforcement of the building structure to provide for the added weight.

Suitable means must also be provided for carrying the current to the lamps in all positions and when the installation is to be made in a glass studio, it must not obstruct the sunlight nor cast shadows.

When it comes to the reckoning, a system meeting all these requirements will cost a very substantial sum and should be planned by a skilled structural engineer, guided by someone well versed in the requirements of the studio.

In one of the modern studios in the east, the lamps are hung from four independent transverse carriages, each movable longitudinally through the studio. Each carriage is provided with a platform, easily reached from a fixed platform with stairway on one side wall of studio running the entire length. From these platforms the electrician has

access to the lamps, electrical connections and raising and lowering devices. The individual lamps are hung in tracks on these transverse carriages and are thus movable to any position across the width of the studio. Each lamp takes its current through contact shoes from properly protected bare copper feeders strung along the carriages. These feeders on the movable carriages pick up the current through larger contact shoes from a set of stationary bare copper mains strung along the side wall and connecting with the switchboard. The top lights are thus all controlled from one switch.

When a light effect is called for, requiring one or a number of top lights, controlled independent of the rest; provision is made for this in the following manner:

Each lamp is connected to its respective contact shoes through a separable plug with a short piece of flexible cable. In the center of the studio, throughout its length and above the transverse carriages, there is an auxiliary feeder run in conduit, from which are hung at intervals, pendant cables terminating in plugs which fit the plugs attached to the lamps. Thus, any of the carriages may be moved to a desired position, one or more lamps thereon disconnected from the trolley feeder and plugged through the nearest available pendant plugs to the auxiliary feeder which is under separate switch control on the board.

This equipment has proven quite satisfactory, but is cited here merely as an example and not for any superiority over numerous others now in use.

In the dark studio, where sunlight is never available to the camera, it is practicable to dispense with the carriage system by lining or studding the ceiling with lights properly spaced and wired for individual control, so that wherever a set may be placed on the floor, top light is provided by simply switching on the desired lamps. Provision should however be made for raising and lowering the lamps individually, to meet the various conditions.

FLOOR LAMPS

It is hardly apropriate to suggest here, either the kind or quantity of lamps required for any assumed condition, but it is important that all floor lamps be sturdy in construction and light enough in weight to be readily portable. They should be fitted with easy running swivelled rollers of large diameter so that they will readily ride over floor obstables.

The lamps are continuously moved from place to place and ease of handling is very much desired.

Stage cables of 25 ft. length or more, are usually attached to the lamps and dragged about with them. It seems a good suggestion to fit each cable with a separable plug close to the lamp, so that the lamps and cables may be separately moved and quickly reconnected.

DISTRIBUTION OF CURRENT TO FLOOR LAMPS

A simple, safe and flexible arrangement of current distribution, devised by the writer several years ago, is described as follows:

Along both side walls of studio a series of plugging boxes is arranged. Each box consists of a 3-wire 100 ampere (per side) plugging pocket, fed by rigidly installed wires from the switchboard. The boxes should not be more than fifteen to twenty feet apart and about four feet above floor. The pocket openings should be downward. This will prevent their being used for ash trays or storage receptacles.

To each of these pockets is fitted a 3-wire plug attached to a 3-wire stage cable of equal capacity, 20 to 30 feet in length. Each of these cables terminates in a portable spider or plugging box having four 2-wire pockets each of 50 ampere capacity.

The plugs fitting these pockets are attached to the lamps by stage cables of suitable length, usually about 25 ft. In this way each wall pocket would supply four lamps of 50 amperes or less, with a large radius of movement for the lamps.

The switchboard is fitted in addition to the top light switches, with one switch for each plugging pocket, each switch being triple-pole, double throw, with the blades connecting to the plugging pocket. One throw of each switch is connected to a set of bus bars fed through a master switch, the other throw of each switch is connected to a separate set of bus bars, fed either through another master switch or direct from the service.

This enables the electrician to set his switches and lamps so that upon signal he can turn on or off a portion of the lights in a set without disturbing the rest; so that a light change can be played in a scene. In the old days this was usually done by holding the action, stopping the camera until the light change was made and then resuming action.

Before concluding, I want to dwell upon the use of alternating current in the studio.

In the third report of the Society proceedings, a reference is made (Paragraph 6 Report of the Committee on Electrical Devices) to the use of alternating current in the projection arc. The objections cited apply here with only this difference, that in projection there seems no real remedy except converting or rectifying to direct current, while in the studio the remedy is simple on account of the plurality of the light sources. All that is needed, to overcome the phase flicker, is a two phase installation with the lamps properly distributed and balanced on the phases.

A word of caution here to the camera man may save him many feet of retakes.

The exposure variations resulting from phase flicker become particularly pronounced on close up, dissolves and fades. This is due to the variations in the exposure period as the shutter opening in the camera is varied, and as close ups are often made with a single lamp, a flicker results, much more pronounced than that in alternating current projection, where at least the shutter value is constant.

To obviate this, never use a single lamp on alternating current, but always arrange the lamps in pairs connected on opposite phases; the results will surely justify your taking the trouble to see that this suggestion is carried out.

In conclusion, I want to say a word in behalf of the man behind the camera. This subject intimately concerns him; for he is the one who assumes almost all of the responsibility of the lighting. If he is to carry the blame for failures he should also have the exclusive say as to the arrangement of the lights.

Let the camera man make himself thoroughly conversant with lighting and the physical characteristics thereof which aid or disturb the results he seeks to attain, so that the director may be justified in entrusting to him this important phase of the work.

Thus, let Science wait on Art, and good judgment on both.

Condensers

By C. Francis Jenkins

In optical projection, the lantern slide, or the single frame of the motion picture film, is simply a stencil to let directed light therethrough to a receiving screen upon which the enlarged stencil is imaged. This stencil may be opaque with transparent portions, in definite arrangement, as in titles, or it may also contain half tones as in pictures. If light filtered by this stencil were projected from a point source, a projection lens would be unnecessary.

Sharpness of image on the screen depends, therefore, on those rays of light which meet most nearly in a point at or near the shutter position, and in the exact axis of the projection system. All other rays tend to blur the image on the screen though adding to the illumination.

For proof of the first proposition one has but to shift the position of the light source considerably to one side of the axis of projection, while still keeping the aperture fully illuminated, a position which gets no picture at all on the screen; and in proof of the second proposition, to observe that a light source of large area will not, even with the best lens, put as sharp a motion picture on the screen as a point source.

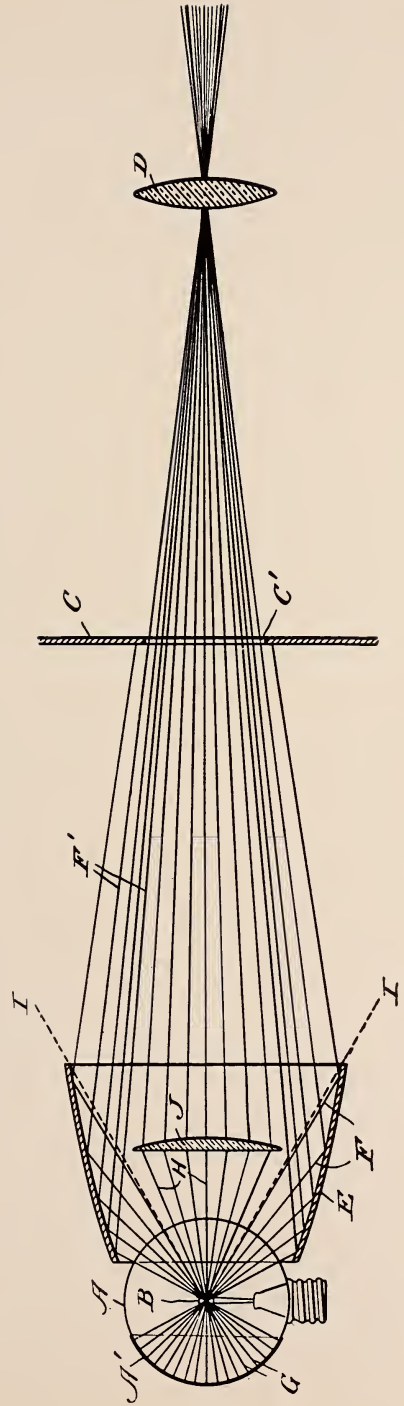
If one had a large stencil to work with, as a lantern slide, a fairly good screen picture could be had with a rather large light source, but as the motion picture frame has less than one-eighth the area of the slide, the most concentrated and intense source of light is required and the highest possible corrected lens.

Given, therefore, a well-corrected lens which will make a picture in spite of defects in the light, further improvement in the system must be in an effort to gather the greatest amount of light and direct it through the stencil of the frame, in the most right lines to a common point, and with the least possible loss.

Designers of early motion picture projectors had the misfortune to begin by using the two thick, light-wasteful, glass condensers employed in magic lanterns. In the lantern the condensers must have a diameter greater than the diagonal of the slide, hence the selection of the 4½-inch diameter in lanterns.

But as the diagonal of the motion picture frame is less than 1¼ inches, a thin, 2-inch condenser would have been quite ample, and we would have avoided the great light loss in the use of 4½-inch condensers, and which has been variously estimated by different authorities to be 75 to 80 percent. Which simply means that if we could effectively employ it, 10 amperes of electric current would do our work where 40 amperes is now required.

Any conservation of light lost between the source and the aperture frame is, therefore, well worth our best efforts, and to determine how we shall proceed, we should analyze the losses and seek the sources. Certainly one of the most glaring is the light reflection and absorption loss and chromatic fringing of the glass of the present system of condensers.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The obvious method would be to avoid the light absorption loss by using only thin lenses, and to usefully employ light now lost by reflection. Not only would thin lenses avoid absorption loss, but also the prismatic fringes at the blunt-angled edge of the lens.

Keeping well in mind the single fundamental requirement laid down initially, namely, that all rays from the light source should meet at a common point, we find that the most divergent rays, plus those lost by prismatic refraction, can readily be reflected, while those of smaller angle with the axial ray are easily concentrated by a small, thin lens, the total forming an almost ideal cone illuminating the aperture stencil of the frame, and with surprising and gratifying conservation of light.

I think few of us have ever considered the loss resulting from the differences in areas of the rectangular aperture and the circular light spot thereon. The light spot on the aperture plate is often 3 inches in diameter, more frequently 2½ inches, and never less than 2 inches in diameter, including in each case the color fringe. The areas of these spots are 6.75, 4.65 and 3 square inches; and because the area of the aperture is but three-fourths of a square inch, the actual light loss from this cause is 89, 84 and 75 per cent respectively. In other words, we waste from three to six times as much light as we usefully employ. This is not a very creditable showing.

Immense advantages would accrue from any considerable saving of this loss, and while I do not say that this is attainable, neither will I say that it is impossible, for my observation has been that the man who says a thing can't be done has his heels tread upon by the man who does it.

Believing that improvement is worth striving for, my own plan for attacking the problem of light conservation in motion picture projecting machines has been along the lines of eliminating the reflection, chromatic and absorption losses.

A considerable part of the absorption loss is avoided by using a single, thin lens; the chromatic loss by avoiding the prismatic edge of the usual blunt-edged condenser lenses, and reflecting this as white light toward the aperture together with the usual lens reflection loss.

The sketch herewith illustrates how this may be attained, though it may not be the best possible means that can be devised.

The lens converges those rays of light which would be lost in the angle bounded by the dotted lines; the light which would be lost rearwardly is reflected into effective position by the spherical mirror, and all others are directed in the right channels by a single reflection. The whole of the spot is white light and can, therefore, be much more concentrated because there is no colored fringe.

As a general observation I might add that considerable confusion seems to exist regarding the optical system of the motion picture machine, whereas it is not at all complex, consisting as it does of two distinct elements, a reversed camera, and a concentrating illuminating system, and which combined are scarcely less simple than either alone. The first motion picture machine, both my own in 1892-94 and Prof. Lumiere's, of France, practically coincident, were combination camera-projectors, the camera part remaining integral, with a lighting system added thereto when projection was desired.

The Portable Projector; Its Present Status and Needs

By Alexander F. Victor

Those of you who ventured into the new and untried, in the days when the motion picture was an undeveloped possibility, may recall that the first projectors were readily and easily portable. At that early stage of the industry, motion picture projectors were made as attachments to such types of optical lanterns as were then in use.

Film reels were rarely over fifty feet in length; and the usual method of manipulating was to run them through into a box, to be re-wound after the entertainment.

A later innovation was to run them in an endless fashion over a series of spools, lengthening the projection until the audience tired of the film episode.

Never-to-be-forgotten classics were "The May Irwin Kiss," and "The Watermelon Contest." "The Baths of Milano," a Lumiere product, added a full measure of enjoyment to many an evening's entertainment.

I do not know who first realized and expressed the magic possibilities of visualized story-telling. The first reaching-out in this direction that I personally saw, was the "Spanish Bull Fight." This subject was taken and shown by the Electragraph, a projector employing a film somewhat larger than at present used.

The next was the Corbett-Fitzsimmons fight at Carson City. I do not recall the exact footage of these films; but at that time they seemed very impressive.

A little later, an eager explorer reached out and placed a new milestone in the land of the motion picture industry, in the shape of a film dramatic production. Heretofore the "movie" had been a novelty without a permanent field and following. With the advent of the story, the motion picture became an essential part of the people's entertainment.

With the evolution from the short-story to the novelette, and thence to the complete novel—the film length increased amazingly.

The small apparatus of twenty-five years ago naturally proved inadequate to properly handle and project film reels, measuring ten inches and more in diameter. The many mechanical requirements necessary to a creditable performance all conspired to make the portable projector an impossibility. The arc lamp and it's housing; the take-up mechanism, and the resistance element, added weight and subtracted portability.

In spite of these handicaps, the inventor has consistently striven to keep pace with the ever-increasing demands upon his ingenuity.

At this moment, it would seem that the limit in film length had been attained. The film width and reel length have been established by this Society.

Aided by the very able Lamp Engineers—who have produced a wonderfully efficient type of incandescent lamp—the designers of portable projectors have been enabled to produce a machine which successfully handles film reels of one thousand foot length. A projector which delivers a satisfactory ten or twelve foot image, of standard i lumination, is extremely compact, easily transported and weighs twenty-five pounds or less.

Motion pictures whenever and wherever you want them are an accomplished fact. Wherever the ordinary illuminating voltage is obtainable—flickerless, brilliant motion pictures are possible.

The portable projector is the logical successor to the optical lantern. It does not enter into competition with its larger prototype—the professional projector; but in the home, in the class-room, in the church and in the equipment of many salesmen, it fills an individual need in a most gratifying manner.

However, in spite of its more than worthy performance and its own most creditable record—the portable projector finds itself in a class of ethical outlaws, due to the company it keeps. No projector, no matter how conscientiously constructed, can take the "flam" out of inflammable film. The professional projector accomplishes the operation by means of the fire-proof booth.

The portable projector becomes equally safe with the addition of the same booth—and accordingly loses its portability. No user could consistently arrive at the place of entertainment, carrying in one hand a truly portable projector, weighing about twenty-five pounds; but in the other hand, a fire-proof booth, weighing five hundred and fifty pounds.

Small wonder that a number of manufacturers, in their eagerness to meet the uncompromising public demand, are supplying portable projectors disguised as sample cases, lunch boxes and violin cases. What cannot be done with safety, according to official requirements, is always accomplished by stealth—with the same lack of safety.

Personally, I do not believe the portable projector to be unduly hazardous, when used in offices or factories—even though inflammable film is used. *But*, when such machines are used, employing inflammable film without booth, in schools and churches—where the apparatus is frequently stationed in the center of a crowded room—then the risk is unwarrantable; unless the operator is skilled and cool-headed.

The amateur, with his indiscriminate use of the portable projector, is a menace to public safety and the good repute of the industry.

There is but one remedy for the present intolerable condition. So long as the market exists—portable projectors will be supplied. Since the uses for which portable projectors are intended, preclude the use of booths—they will be used without.

Since the film employed is the fundamental fault—corrective measures must be applied in that direction. Hence, the non-inflammable film.

This is not a new need; much has been said, but little has been done to alleviate conditions.

Except in one notable instance, manufacturers of portable projectors have listened to the siren song of the argument that only projectors using the standard films would be accepted—owing to the tremendous list of available subjects.

This impressive supply of film has been greatly over-valued. Out of the thousands of film subjects available—comparatively few are adaptable to the needs of the portable projector, whose users require principally Educational and Religious subjects.

I venture to estimate that the existing total of such films will not exceed five hundred, and these so scattered as to make it impossible to secure more than a small percentage of them.

The logical thing to do—it seems to me—is not to meet the obvious public demand, which results in an unhealthy condition; but to furnish the public with a product which meets its needs and creates a sound basis for the industry. Since standardization has produced a large library of inflammable film, why not create by the same means a library of non-inflammable film of suitable subjects and equal volume?

If all manufacturers of portable projectors were to combine and adopt a new standard for such machines, it would be but a short time before an enterprising industry would supply an adequate library of film. Since the number of existing film subjects, suitable to portable projectors, is so limited, it would seem quite practicable to arrange to have them reproduced on non-inflammable stock.

The most apparent obstacle to this plan is this: If a new standard is established by this Society and accepted by manufacturers of portable projectors—who is to make the film?

I would again ask those of you who were with the industry at its beginning, to recall the period when there were but three sources from which to obtain film; although there were at least twenty-five different projectors clamoring for recognition.

I, therefore, feel justified in my belief that the adoption of a standardized, non-inflammable film, will be met with a supply of such film.

Create a demand, and invariably the supply comes to hand.

It may be necessary at first for the manufacturers of portable projectors themselves to make and supply a limited number of reels. Each one doing his bit, the impetus is given and the movement is well under way.

I believe the Underwriters' Code, as it is now drawn, to be very just. I do not believe that non-inflammable film of standard width and perforation (even though it carried a definite label) would sufficiently safeguard the public. Many unscrupulous exhibitors would use the wrong kind, and with everyone unconscious of danger, the risk would be doubled.

There is, in my estimation, the greatest need for immediate action in this most undesirable state of affairs.

I respectfully submit a recommendation to this Society, that the following three subjects be taken up for immediate discussion and acted upon:

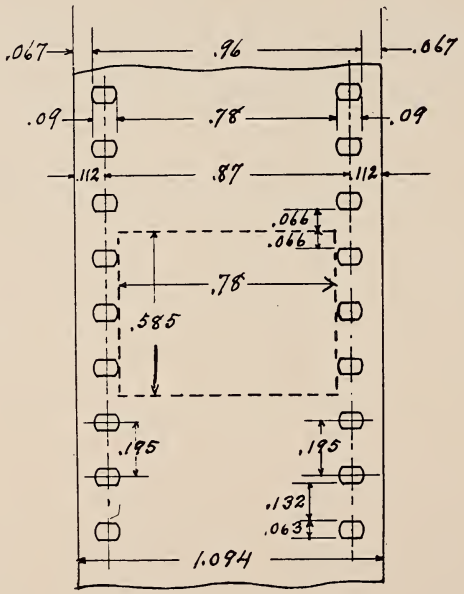
(1) That the present Underwriters' ruling, regarding the use of non-inflammable film be approved by this Society.

(2) That a universal standard be adopted for approved non-inflammable film; so that manufacturers desiring to make and sell portable projectors may co-operate and turn out an interchangeable product.

(3) That the term "Portable Projector" and its definition be added to the Society's list of motion picture nomenclature.

I also submit the following film standard as per drawing, which seems to me to fully meet all requirements. With a standardized non-inflammable film, universally adopted by all manufacturers, a film that will, if possible, permit printing by reduction from standard negatives—I see no reason why the portable projector may not come into its own.

It could thus enter its field of service, unhampered by the stigma of criminal risk; safe-guarding its users as conscientiously as does its big brother—the professional projector.



Theoretical vs. Practical as Applied to Standardization and Some of the Things to be Considered as Proper Subjects for Standardization

By F. H. Richardson

In approaching the problem of applying suitable standards to appliances in common use in the motion picture industry, it is well to remember that the thing which may seem precisely right when viewed from the standpoint of theory may fail utterly under the crucial test of actual practice. This is particularly true where the appliance is to be placed in the hands of an incompetent man, or a man of mediocre ability.

In this connection it is well to consider that insofar as machinery and appliance for the theatre operating room be concerned, a large proportion of it will be handled by men of relatively small ability in the handling of machinery or optical appliance; a very considerable proportion will be handled by men of no ability whatever and only a relatively small percentage will be placed in the hands of those who could by any stretch of imagination be termed experts. Remember, gentlemen, this is the *condition* which prevails and is not easily altered; hence it must be reckoned with. It would be foolish indeed to ignore this condition merely because it ought not to exist. It *does* exist and will continue for at least several years to come.

The effect upon standardization of this condition is, that in operating room machinery standardization, we must studiously avoid the too-delicate. For instance, the spindle which might be perfectly capable of carrying its load under proper conditions at 5-16″ diameter, may carry it far better at 3-8″, 7-16″ or even 1-2″ diameter, if it is to be placed in charge of a man who knows little or nothing about proper lubrication and who is careless and generally incompetent. In other words, it will be well to lean always to the side of generous dimensions in operating-room moving machinery parts. In the fixing of standards for operating-room machine parts we must, for the present at least, take into consideration the conditions under which such machinery will, or may work, else difficulty will surely be encountered.

The question of which particular things require standardization is one which cannot be answered by any one man. In my opinion, the standardization of projector parts should only be undertaken upon the recommendation of the committee on projection machines. This committee should hold meetings and recommend to the body such standards as may seem in its wisdom to be right and proper. Unless this is done, I believe there will be more or less confusion and liability to error. The same applies to cameras, optical appliances and such other things as are covered by committee.

I would further respectfully suggest that any proposal of a standard presented to the body by an individual be not acted upon finally until it has been referred to the committee within whose jurisdiction it

comes, or to a special committee, of which he shall be a member, the committee to consider the matter and make its recommendation at the next regular meeting.

The foregoing is, of course, a digression, for which I trust I may be pardoned because of its seeming importance.

In general there are several things not coming within the duty of any committee, which ought to receive attention from this body, unless it be held that camera speed falls within the field of the committee on cameras.

Camera speed is, perhaps, the one thing needing the attention of this body more than anything else. Lack of uniform camera speed is doing literally tremendous damage to the silent drama, both artistically and physically. The present condition is that different directors or producers adopt their own individual views as to camera speeds, ranging all the way from sixty feet of film per minute to as high as seventy-five. This would be bad enough, but to it is added the variation in speed by individual camera men, who often take scenes intended to join each other in the finished product. This variation runs as high as, in extreme cases, five each way from normal, making a total variation as between adjoining scenes, of ten feet per minute—a variation of two to five feet is quite ordinary. Projectionists, as a rule, either do not or are not allowed by circumstances (running to "schedule") to vary the speed of projection to suit variation of speed as between various scenes in a film; also the schedule for the show is made up without knowledge as to the speed at which the film (footage always known, at least approximately) was taken, hence the reproduction of the photoplay upon the screen is a sort of haphazard, happy-go-lucky performance, which can only be right by pure accident.

With camera speed standardized, the proper time for the proper artistic reproduction upon the film would merely be a matter of dividing the total footage by number of feet per minute standard. Without entering into detail, this would also work out to immensely lessen the physical injury to films, now mounting into the tens of thousands of dollars per day.

For several reasons I would respectfully recommend to this body a higher standard per minute for camera and projection machine. Our present rate is too slow with present powerful illumination and semi-reflective screens. It is not sufficiently high to eliminate flicker under those conditions, especially if the local shutter conditions be bad. Seventy will, on the other hand, place no unduly heavy burden on the film itself, or upon projection machinery, and will eliminate flicker in all but the very worst cases.

Another thing which might well receive attention is the minimum distance from front row of seats to screen, which should, I think, be based upon picture size, but with an absolute minimum of fifteen feet for a ten-foot picture, with one foot of added distance for every foot of added width up to twenty feet.

Exit signs is still another thing which cries to heaven for standardization, though anything we might do in this respect would be at the mercy of ill informed officials and law makers. But this does not ex-

cuse this body from acting. I would respectfully suggest the following: the letters E X I T on plain ground glass, the letters to be of size to comply with local law, and to be blocked out in black, so that light shows through the letters only. Behind the ground glass bearing the letters and between the letters and the illuminant, there to be a sheet of dark ruby glass, or two thicknesses of standard photographers ruby glass. This allows only the letters E X I T to be visible to the audience and in dark red.

Still another proper subject for standardization is the width of black border for screen.

In the operating room itself, aside from machinery, etcetera, the observation ports are in sad need of standardization, both as to width and height from floor, though the latter is difficult by reason of projection pitch. The operating room size also needs attention. Present standards were adopted while projectors were very much smaller than at present. Operating rooms should be not less than nine (9) feet front to back; ten (10) would be better.

Operating room ventilation standardization is necessary, both from the standpoint of health and fire hazard. The state law of Massachusetts will form an excellent basis for study of this subject.

There are other things I might mention, but it seems to me I have said enough (perhaps you may think too much) for one time. I would, however, again utter warning as against adopting standards from the purely theoretical point of view. I have for many years preached to projectionists the gospel of combining theory with practice. I now respectfully ask this body to apply that doctrine in reverse. Be very certain that practice, *as it is*, will combine at least fairly well with theory, before setting up a standard which, while theoretically perfect, will fail when placed in actual operation under the conditions prevailing.

Incandescent Lamps for Motion Picture Service

By A. R. Dennington

ARRANGEMENT OF LIGHT SOURCE

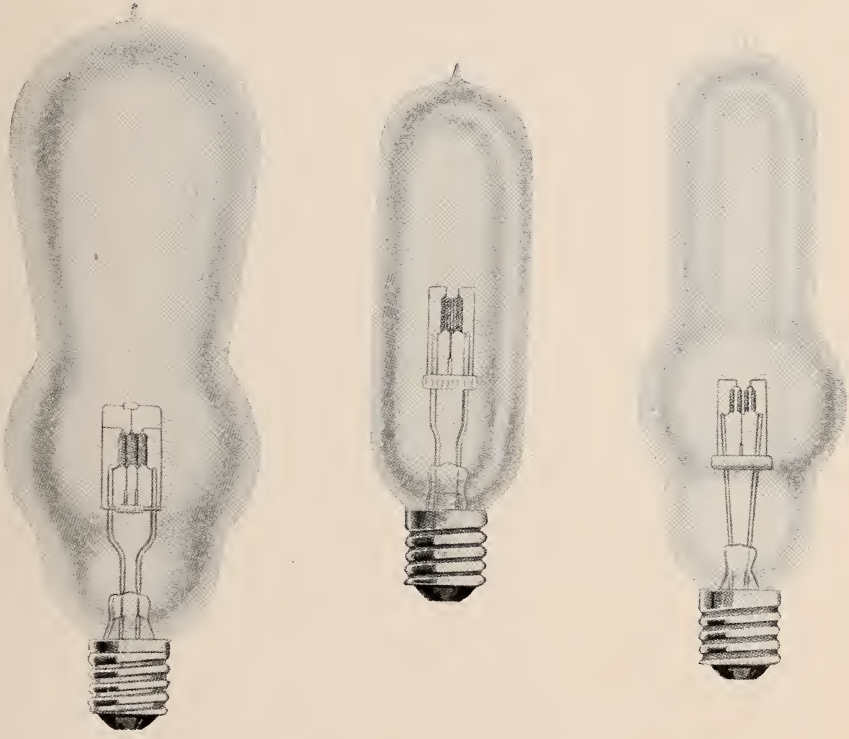
In the development of an incandescent lamp for motion picture service, it is essential to concentrate the light source as much as possible because no condensing system can collect and utilize the rays of light from an extended source. The problem that comes up is, therefore, that of getting as much filament as possible within a given area and arranging this filament in such a way that there will be maximum illumination in the direction in which it can be utilized.

There are in general two methods which suggest themselves for the arrangement of the filament. One method consists in arranging the coils in series and placing the various sections close to each other and practically parallel. This series of coils may be arranged either in planes at right angles to the line of projection, or in a more or less complete arc of a circle. Arranging the coils in the arc of a circle has the advantage of placing each element of the filament equally close to the focal point of the optical system. However, it has the disadvantage that no element of the filament can be placed exactly at the focus and therefore no element is operating at the best possible efficiency for the system. The arrangement of the filament sections in a plane or planes perpendicular to the line of projection has been found to be more satisfactory than the circular arrangement, as it makes possible a more uniform field or beam than can otherwise be obtained. There are, however, spaces between the filament sections which are not sources of light and the result of this is that the screen may have light and dark areas corresponding to the filament areas.

The second method of arranging the filament is to connect the sections in parallel with very small space between them. This arrangement permits of a larger amount of filament within the given area but it has the disadvantage of requiring a high current which is liable to cause heating of the lamp seal as well as the wires and contacts. Any sagging of the coils tends to short-circuit to a greater or lesser extent portions of each section, as the current passes from a turn of one coil to a turn of another coil without passing around the helix, thus reducing the lamp voltage and the candle power as well. If the coils are spaced far enough apart so that there is no danger of the sections short-circuiting by contact with each other, there is little or no advantage of the parallel arrangement of coils over the series arrangement.

In order to obtain some of the advantages of practically an unbroken wall of filament and also retain the advantages of series connected coil sections, an arrangement of the filament has been developed which places the coil sections in two parallel rows, with the coils in the back row opposite the spaces between coils in the front row. This arrangement of the filament presents a solid wall along the axis

of projection as shown at *a* Fig. 1. However, as the condenser picks up light from angles up to 40° there are certain portions of the condenser which receive light only from the front rows of coils, the rear coil sections being hidden behind the front row. A condition of this kind necessitates a somewhat larger amount of energy supplied to the coil for a given screen illumination. This increase in the power necessary is considered of secondary importance, the primary requisite being to get as much illumination as possible on the screen. The two rows of filament are placed as close together as practicable in order that all sections of the light source may be as near as possible to the focal point. Lamps of smaller wattage can have the filament arranged in a single row or plane as shown at *b* and *c*.



a *b* *c*

Fig. 1

The useful area of light source varies with different condensing systems and different projection lenses. Under a given set of conditions, the useful projected area of filament can be determined by testing back from the screen by means of a lamp. A lighted lamp is placed at each corner of the screen after the objective lens has been carefully focussed and the condensers adjusted so as to give the best illumination on the screen. The light source is then removed from behind the condenser and a test plate placed in the position of the filament. The

lighted area on this test plate indicates the area which can be used in illuminating the screen. When the test lamp is placed close to the corners of the screen the lighted area on the test plate shows the cutoff due to the corners of the aperture plate. When the test lamp is moved in from the edge of the screen the spot projected back to the test plate is circular.

A number of tests were made on different types of condensers including the usual plano-convex condensers and also the special Corning corrugated lens of the Fresnel type. With a pair of plano-convex condensers having a 5½″ focus lens toward the light source and a 7½″ focus lens toward the aperture plate, the following results were obtained:

The light source, *a* (Fig. 2), was placed 85 millimeters from the face of the 5½″ condenser (b), and the distance from the face of the other condenser (c) to the aperture plate was 234 millimeters. The two

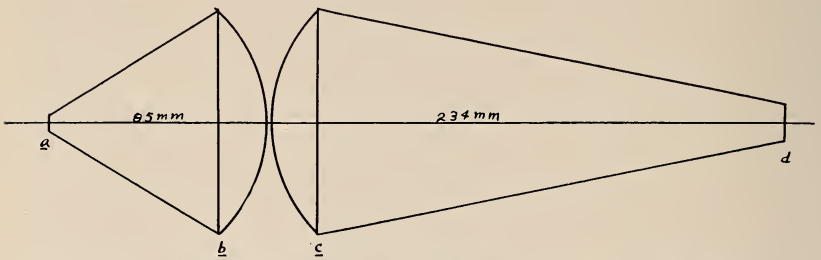


FIG. 2—Arrangement of Plano-Convex Condensers in test for size of light source

condensers were placed so that there was about 1 millimeter clearance between the convex surfaces. Under these conditions, the area of the light source as measured on a test plate is 11 by 13 millimeters, *a*, Fig. 3. The setting given for the condensers and light source were determined after a number of trials and were found to give the best results, both from the standpoint of illumination and uniformity of screen. The total illumination delivered on the screen from a 1200 watt lamp operating at an efficiency of .477 spherical or .315 horizontal watts per candle was 754 lumens. In testing back from the screen to determine the area of the light source, the test lamp was placed close to the screen. When the lamp was placed close to the objective lens, a different light source area was obtained as shown in *b*, Fig. 3. In this case, the illuminated area on the test plate consisted of two parts, one part essentially the same size as before but surrounded by an area of lower intensity. This area measured about 22 by 19 millimeters. These tests indicate that the light source would have a useful area of 11 by 13 millimeters. However, it is advisable to make the source somewhat larger than this, hence the dimensions adopted are about 16 millimeters for the horizontal dimension and 13 millimeters for the vertical dimension of the light source.

In order to determine the effect which would be obtained by back testing through a corrugated condenser having equivalent foci of 2½″ and 8,″ the same method was used as in the preceding test. The

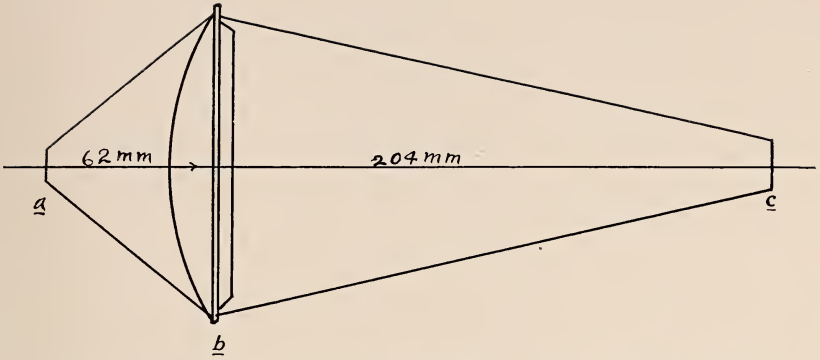


FIG. 4—Arrangement of Corrugated Condensers in test for size of light source

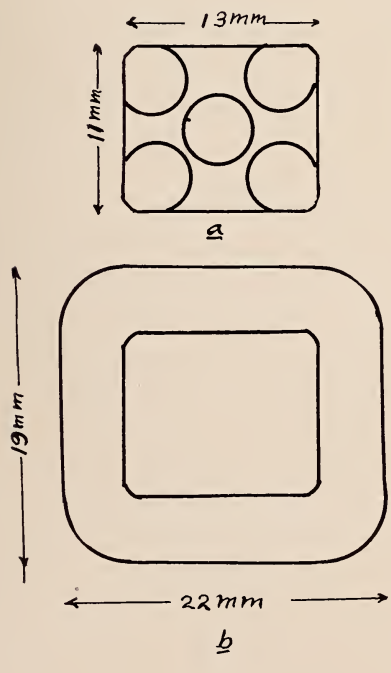


FIG. 3
Light source area for 5½" x 7½"
Plano-Convex Condenser System

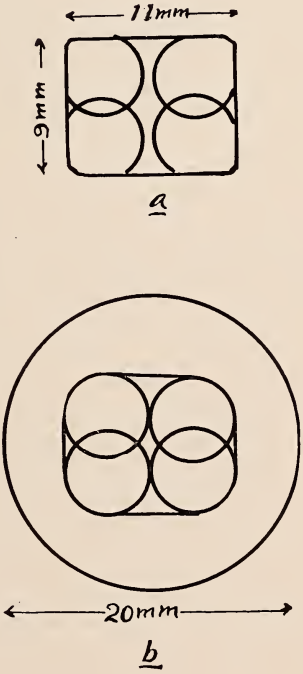


FIG. 5
Light source area for 2½" x 8"
Corrugated Condenser

lamp was set up so as to give the best possible screen, which condition was obtained when the light source was placed at the 2½″ focus and the distance to the aperture plate was practically 8″, Fig. 4. Under these conditions the lamp which had been used in the preceding test was operated at the same efficiency as before and gave a screen illumination of 616 lumens. When the lamp was removed and the light source at the screen was used for back testing, the lighted area on the test plate was 11 by 9 millimeters, *a* Fig. 5. When the test lamp was moved up to the end of the objective lens there was still an area of 11 by 9 brightly lighted on the test plate, but this was surrounded by a circle *b* 20 millimeters in diameter. It was noted that the circles which were projected back from the test lamp were somewhat larger than with the plano-convex condenser, showing that the corners of the screen were illuminated by a somewhat greater proportion of the light source. The test also indicated that the corrugated condenser did not utilize as much of the filament area as did the plano-convex condenser.

EFFECT OF MIRROR ON LAMP RATING

In order to determine the effect which the mirror has on the temperature of the lamp filament when the latter is placed at the center of curvature of the reflecting surface, tests were made on both monoplane and biplane lamps. The lamp ratings given in Table 1 were taken without a mirror focused on the lamp filament. Temperatures were measured both with and without the mirror as shown by the values in the last two columns.

Table 1—Effect of Mirror on Filament Temperature

LAMP	W.	V.	Amps.	H. CP.	H. W. P. C.	S. CP.	S. W. P. C.	Temp. Without Mirror	Temp. With Mirror
Monoplane	806	26.	31.	2560	.315	1480	.544	3200°K	3245°K
Biplane	1192	42.3	28.2	3900	.3055	2500	.477	3275°K	3325°K

It will be noted that the effect on the temperature of the filament is essentially the same with the monoplane and biplane construction. This is probably due to the fact that in the monoplane construction the coil sections are spaced as closely together as practicable so that the distance between coils is considerably less than the diameter of the coil. The reflected image of the coil, therefore, instead of passing between the coils comes back on the coil to a greater or lesser extent. In the biplane lamp, the reflected image of the coil comes back partially on some portion of the coil and partially on the spaces between so that in the two cases, the temperature conditions are very nearly the same, the table indicating differences of only 5° with the two coil constructions. If the spaces between the coil sections of the monoplane coil were increased the temperature would probably be somewhat less than indicated, but the screen illumination would also deteriorate because it would show the spaces between the coils.

The effect of a properly focused mirror on increasing the illumination on the screen is indicated in Table 2.

Table 2—Effect of Mirror on Screen Illumination

LAMP	CONDENSER	MIRROR	LUMENS
Biplane No. 21-10	Corning—2½" x 8"	None	467
" " 21-10	" —2½" x 8"	M. E. 8"	584 Gain by mirror 24.6%
" " 21-10	Plano-Convex 5½ & 7½	None	544
" " 21-10	" " 5½ & 7½	M. E. 8"	712 Gain by mirror 30.8%
" " 21-11	Corning—2½" x 8"	None	556
" " 21-11	" —2½" x 8"	M. E. 8"	681 Gain by mirror 22.5%
" " 21-11	Plano-Convex 6½ & 7½	None	575
" " 21-11	" " 6½ & 7½	M. E. 8"	686 Gain by mirror 19.3%
		Average Gain by mirror 24.5%	

The mirror in each case was a Macbeth-Evans spherical mirror, having an 8" diameter and 5 5-8" radius of the reflecting surface. The gain due to the use of the mirror in the tests ranges from 30.8% to 19.3% and gives an average gain of 24.5%. All of these tests were made with biplane filament lamps. Two different lamps were used and two different combinations of plano-convex condensers. A further test was made using biplane lamp No. 21-10 in order to determine how much the current supplied to the lamp could be reduced in order to give the same illumination as was originally obtained with this lamp without the mirror. This test showed that changing the current from 28 amperes on a lamp used without a mirror and giving a screen illumination of 544 lumens to 27 amperes on the same lamp with a mirror, gave a screen illumination of 564 lumens. This change in current in the lamp is equivalent to a change of about .06 in spherical watts per candle. However, there is a gain due to the use of the mirror which is not accounted for by the change in current and the resulting change in temperature of the lamp filament. This gain is due to the light from the reflected image of the filament which tends to give a more uniform light source so that the illumination on the screen is more uniform and of higher intensity than can be obtained from the filament alone.

CONDENSER SYSTEMS AND OBJECTIVE LENSES

A number of different condenser systems have been tried out in the development of apparatus for the use of incandescent lamps in motion picture projection. The two which have given the best results are the corrugated type of condenser and the plano-convex condenser systems. Each of these condenser systems possess some advantages and also some disadvantages in comparison with the other, and it is a matter of choice as to what points should be sacrificed in making a decision as to the type of condenser. One advantage of using the plano-convex condenser system is that the working space between the lamp house and the head of the motion picture machine is great enough to permit of easy manipulation of the framing lever or to make any adjustment to the film which may be necessary. There is also another advantage in that the angle at which the light rays converge is more acute and therefore there is less loss in picking up the cone of light beyond the aperture plate and collecting this cone in the objective lens. This is especially true where a fairly long focus objective

lens is used. Motion picture machines which are in use at the present time are constructed with a lens tube or holder about 2″ in diameter. If a lens larger than this holder is to be used, it is necessary to have an adapter, which reduces the opening to the lens to the 2″. In this way, a part of the area of a 2½″ diameter lens is unavailable because the light rays strike the sides of the holder before reaching the lens. The disadvantage of the plano -convex condenser is that there is some tendency to show a more or less imperfect image of the coils of the lamp filament on the screen. This tendency can be reduced to a minimum by careful focusing of the lamp and by use of a mirror back of the filament. It is possible to produce a screen which is so nearly free from iridescent streaks that it is not in the least noticeable when a picture is being shown, though there may be slight traces of the streaks on the open screen when there is no film in the machine. Lantern slides can be shown with the plano-convex condensers and this is a condition which must be considered. The corrugated condenser has the advantage of giving a somewhat more uniform screen illumination than can be obtained with the plano-convex system. It has the disadvantage of requiring a very short working space between the lamp house and the head of the motion picture machine. Lantern slides cannot be shown with this condenser and an auxiliary set of plano-convex condensers is necessary. The condenser also has such a short focus that the rays of light converge at a much more obtuse angle than the rays from a plano-convex condenser and therefore a greater portion of the cone of light passing through the aperture plate is lost and is not picked up by the objective lens.

SHUTTERS

The use of incandescent lamps on alternating current circuits will result in improved screen illuminations because of the fact that the filament stores up heat and maintains a practically uniform temperature throughout the current cycle. In an arc lamp, the intensity of light varies as the current alternates. It is because of this periodic variation in the arc that it is necessary to use a two-wing shutter on motion picture machines which are being operated on 60 cycle alternating current circuits. With a two-wing shutter, the picture is normally cut off 32 times per second. This frequency of cut-off is so far different from the frequency of the light variation due to the alternating current that there is no tendency for the two to come into synchronism. However, if a three-wing shutter is used the picture is cut off 48 times per second. This frequency of cut-off is so near the frequency of the current that there is a periodic variation in the screen appearance due to the fact that the light is dim because the current is near zero value during the time that the shutter is open and later the picture is cut off entirely by the shutter wing. Later the light is bright while the shutter is open and the result is a periodic variation in the brightness of the picture. It will be dim for a short space of time and then it will be bright for a corresponding period. This condition has led to the adoption of the two-wing shutter as the standard for alternating current circuits. The two-wing shutter possesses the disadvantage of operating at such a low frequency of cut-off that there is

usually a decided appearance of flicker on the screen. With a gas-filled incandescent lamp on an alternating current circuit the light is steady and therefore a three-wing shutter can be used with the result that the frequency of cut-off of a picture is sufficiently high so that there will be no noticeable flicker.

In the use of wide aperture objective, to secure as much illumination on the screen as possible, the shutter should be considered. If the shutter is not adapted to the wide aperture lens, it will not cut off the light from the screen during the period of picture travel and there will be the appearance of a travel ghost. This may be seen especially when titles are being shown as it tends to cause a stringing out or fuzziness of the tops and bottoms of the letters. Most of the shutters for machines have been designed for use with the smaller lenses and the wings are not wide enough to take care of the wide aperture lenses. If the shutter diameter remains unchanged and the lens is very greatly increased, the angle through which the shutter must move in order to cut off the light from the screen is decidedly increased, thus resulting in a slower cut-off and a corresponding reduction in the time that the full lens aperture is utilized while the film is stationary. The use of a shutter with a diameter correspondingly larger is desirable where a wide aperture lens is used, though in most cases such a change in the shutter size cannot be made conveniently. The only thing which can be done to minimize the difficulty is to proportion the wings of the shutter so as to eliminate the travel ghost and at the same time get as much light on the screen as possible.

SCREEN ILLUMINATION

The useful light which is delivered to the screen is the final test of the effectiveness of any system of condensers and lenses which may be used. The object is always to produce the brightest and most uniform screen possible with a given source of light. It is no disadvantage to have the illumination in the center of the screen somewhat greater than near the edges because the greater part of the action in the pictures is well toward the center; however, there should be sufficient light at the edges to show up details and the screen should not be so uneven that it is noticeably brighter in the center than at the edges especially when titles are being shown. If the difference between the center and the edge illumination is too great, titles will show up clearly in the center and will fade off toward the ends of the lines so that it is difficult to read the complete message.

A typical screen illumination is shown in Fig. 6. The figures in the center of each square represent the actual foot candles on a small screen having an area of 27.75 square feet. The total illumination delivered to this screen is 693 lumens. The intensity of illumination in the corners is approximately two-thirds the intensity in the central portion of the screen and this ratio is not too great for the satisfactory projection of pictures.

The color of the light delivered by an incandescent lamp has a warmer tone than the light from a carbon arc and therefore the pictures do not have that hard chalky appearance which is sometimes noticeable in pictures projected by high-powered arcs. As the illumi-

20	24	2.37	19
22	27	32	2.35
23	32	27	23
20	2.75	25	20.5

FIG. 6—Diagram showing foot candle intensities on screen having an area of 27.75 sq. ft.; 693 lumens

nation is steady the eye can be more comfortably focused on the picture than where the light intensity is varying as is always the case where arcs are used.

A comparison of the intensities obtained on a screen with a 40 ampere direct current arc and 1200 watt lamp is shown in Fig. 7. These intensities give approximately equally satisfactory pictures; that is, the audience could not determine which lamp was in use. In this test the illuminometer was arranged so that its field of view covered practically the entire surface of the screen and readings were taken at intervals of 15 seconds for a period of 10 minutes. The scale used is an arbitrary scale and does not show the actual foot candle values of the light reflected from the screen.

LAMP-HOUSE EQUIPMENT

When the filament of an incandescent lamp is once placed at the proper point in the optical system it remains in this position for the life of the lamp. Changes in the focus are necessary only when lamps are changed. For this reason it is possible to adjust a lamp so that the filament occupies a predetermined position with respect to a base plate or holder which can be slipped into the lamp-house or removed at will. After the filament has been adjusted with respect to this holder, the lamp and holder can be very quickly placed in service in the machine in case of a burnout. The only thing necessary is to remove the burned out lamp and holder and substitute the new holder with its lamp properly adjusted.

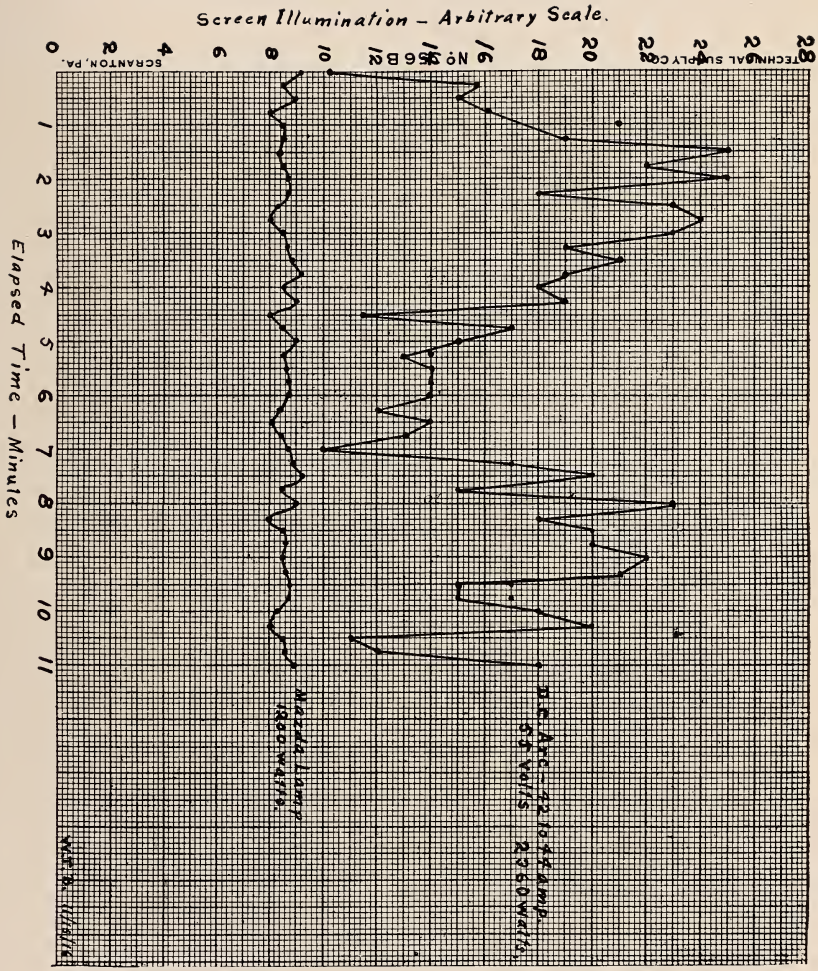


Fig. 7—Variation in screen intensities D. C. arc and Tungsten lamp

Mechanism has been developed which permits the focusing of lamps entirely independent of the optical system of the machine. It has been demonstrated by actual test that more uniform results can be obtained in this way than can be obtained by focusing each individual lamp in the system by judging the appearance of the screen by the eye. There are certain modifications of this equipment which include a part or all of the features which have been outlined.

ELECTRICAL CONTROL EQUIPMENT

The lamps for motion picture projection are operated at extremely high filament temperatures. It is necessary, therefore, that the current supplied to the lamp be closely regulated as, otherwise, satisfactory lamp performance cannot be secured. If the current is reduced below that at which the lamp is rated the intensity of the light is diminished while if the current is increased above the rated value there is danger that the lamp may fail very shortly.

In order to keep the current at the desired value it is essential that an ammeter be included in the lamp circuit. Where the lamp can be supplied from an alternating current circuit it is possible to use a transformer equipped with an ammeter and a regulating device. The regulating device may consist of a switch which connects different taps of the secondary to the lamp in order to obtain the current control, or may consist of an adjustable reactance. The reactance method of controlling the current has the advantage of permitting very accurate adjustment of the current and voltage. This is of primary importance and the transformer is not a serious disadvantage. In fact under the worst conditions the power factor of the control equipment for incandescent lamps will be higher than the power factor of arc lamps with reactance coils which are often used. The power required by this lamp is less than the power required by the arc, so that existing circuits in the theatres will be ample to supply the new lamp and the voltage drop will be less than when the arc is used.

It is important that the rush of current through the lamp at starting be kept fairly low in order to protect the ammeter and reduce the danger of cracking the lamp seal at the point where the leading-in wires pass through the glass. The resistance of the lamp filament is very low when the filament is cool and as the filament is large there is an appreciable time before it heats up so as to limit the current. If no method is used to limit the starting current the initial rush is momentarily many times the normal lamp current.

Some Consideration in the Application of Tungsten Filament Lamps to Motion Picture Projectors

By L. C. Porter *and* W. M. States

The fact that there are today in operation approximately one thousand motion picture machines using the tungsten filament lamp as a light source proves that the incandescent lamp is a success in this field. The history of the developments which were gone through to achieve this success is very interesting. Some of the lamps and apparatus, which a short time ago seemed marvelous, today appear almost crude. However, we shall not take your time to describe the discouragements and the achievements along this line during the past three years. Nor shall we devote much time to description of the fundamental differences between the arc and the incandescent systems. This data is already more or less familiar to you, through papers presented before your Society, through articles in the trade journals, and through commercial advertising of the concerns manufacturing projection equipment.

In starting anything new there are always interesting developments which come through practice. Unforeseen difficulties arise and new methods of operation are established. It is the purpose of this paper to call attention to some of the practical considerations which have been found of material assistance in getting the best out of the incandescent projector. We wish to present data which will assist the manufacturers of motion picture equipment to realize the great advantages of accuracy in the optical system. We also hope to describe little "tricks of the trade" which will be of service to the users of projection equipment.

Few engineers or operators realize fully how closely it is possible to work with the incandescent system. In the arc system there must be more leeway. The carbon crater covers considerably greater area than is actually necessary, so far as light utilization alone is concerned. However, the arc is more or less unstable. It wanders around, and hence some allowance must be made to meet that condition. Shading by the negative carbon, and feed requirements constitute a very complex handicap. In other words, with the arc it is necessary, on account of these variations, to use larger carbons and more power than would be required if the arc could be held in a fixed position. Each optical system has a definite area over which it will pick up light. Any flux originating outside of that area adds little to the resultant screen illumination. Let us examine (Fig. I), a diagrammatic sketch of the optical system of a moving picture machine.

Assuming that the light originates from the arc A the paths of the extreme rays may be indicated by lines B and C, terminating on the motion picture screen. Suppose we have another ray of light, D, originating a considerable distance outside of the arc crater. It will be bent by the condensers similarly to rays B and C, and therefore, will not fall on the objective lens and will not reach the screen. This ray D

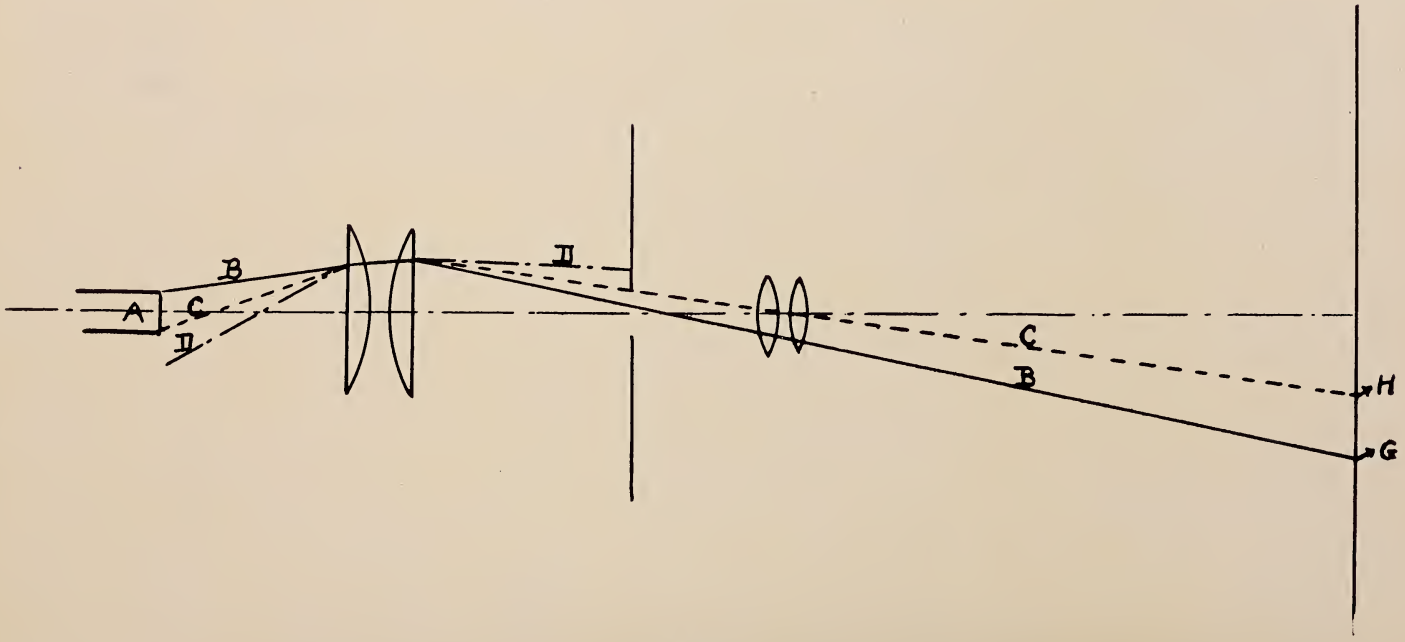


Fig. 1

of light originates too far from the focal point of the condenser to be of service. It, therefore, becomes evident that there is a limit to the size of light source which can be utilized. There is a very simple method of determining that size. Let us send the light rays backwards, *i .e.*, suppose the screen were illuminated by another machine or suppose it were made of translucent diffusing glass and lighted from behind, then the ray of light starting at point G on the screen would follow back along the path of the previou ray B. Similarly a ray originating at point H, and so on for every point on the screen. If we replace the arc crater by a piece of ground glass or oiled paper, an image of the screen will be formed on this glass. By moving the ground glass forward and backward, a point will be found where this image will be smallest and its edges sharp. That lighted area then is the maximum size area possible to utilize as a light source. All light rays originating within that area, and falling on the condenser will be projected on to the screen. It is not always convenient to light the screen by another machine and even if it is, the intensity of the reflected light finally reaching the ground glass is low. A more convenient method is to place a piece of translucent diffusing glass (such as heavy density opal) directly in front of the objective lens and hang an ordinary tungsten filament lamp in front of this, (Fig. II).

This method of determining the useful size of light source is called back-testing. Let us take a specific example, a machine equipped with a 4½″ diameter, 6½″ focus rear condenser lens and a 4½″ diameter, 7½″ focus front lens and a 1¾″ diameter, 5½″ focus projection lens. Back-testing it we found the maximum light source size to have an area of .188 sq. in. In practice, this machine operates with 5-8″ diameter carbons burning at an angle. The actual area of the crater is .368 square inches, .18 square inches or 95% greater than the maximum, useful, light source area. This extra amount is, however, considered necessary due to the utter impossibility of keeping the arc crater fixed in one spot, and on account of the shading by the negative carbon (which is most at low currents.)

Having this extra area of light source available, slight variations in alignment of the optical system do not materially affect the total amount of resultant screen illumination, though colored borders and ghosts are apt to appear. This, however, is not so with the incandescent lamp. The filament of that light source is of fixed area and remains *exactly* where it is put. Under these conditions a filament has been designed to fill exactly the maximum useful area of the lens system. This area for the lens system at present in use is a square 4-10 of an inch on a side or having a total area of .16 of a square inch.

Let us suppose, for example, that in setting up the lamp in the machine an operator fails to center the lamp filament properly in the 4-10 of an inch useful area. Suppose it is 1-10 of an inch to one side. We then have the condition shown in Fig. III, only ¾ of our light source is within the useful area. This will result in a very material lowering of the screen intensity. Not only is there a loss of light, due to a portion of the filament being outside of the useful area, but also the beam projected by the condenser is bent to one side, and hence much light is spilled on the aperture plate instead of passing through the aper-

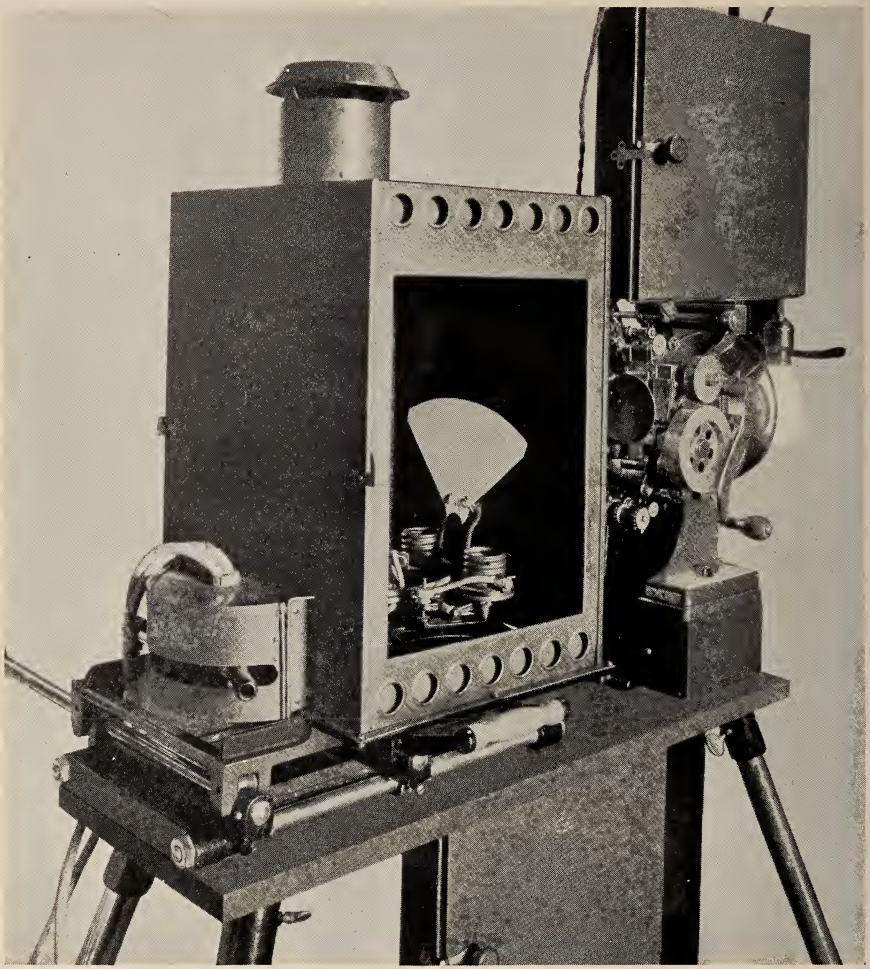


FIG. 2

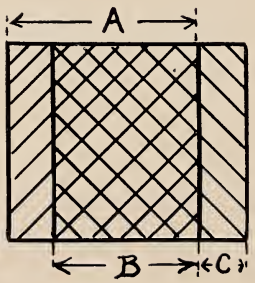


FIG. 3

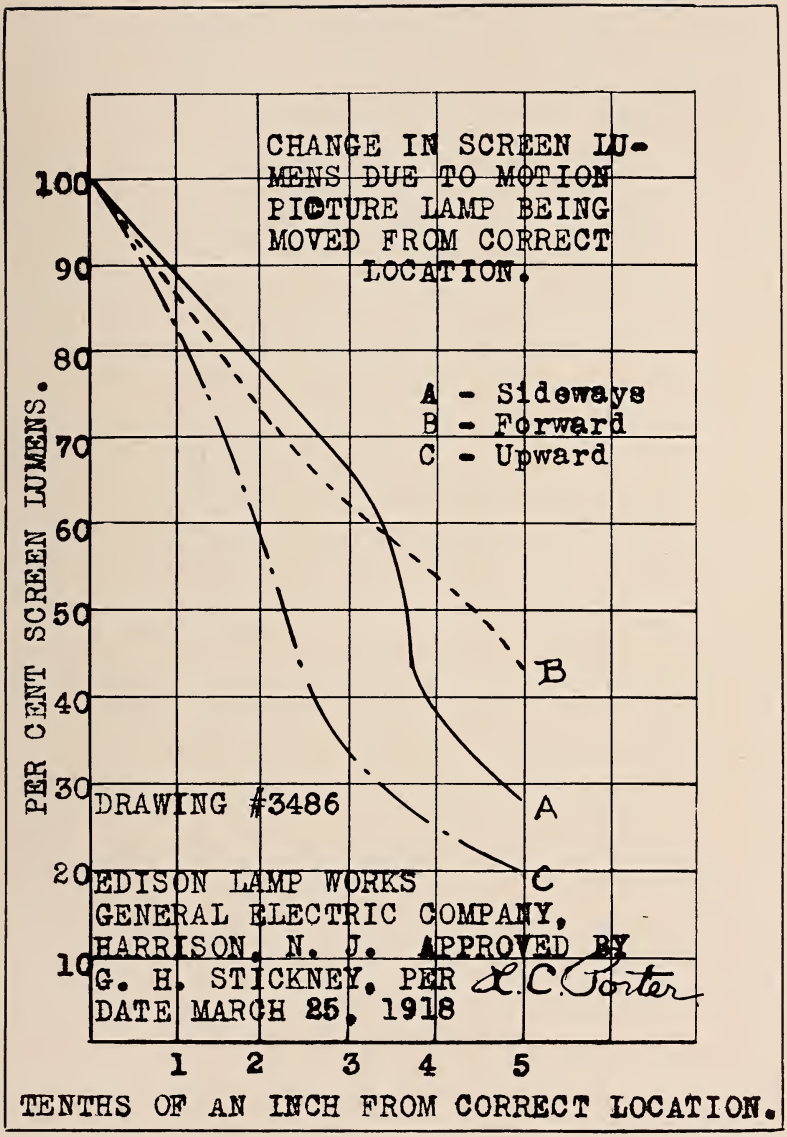

CHANGE IN SCREEN LUMENS DUE TO MOTION PICTURE LAMP BEING MOVED FROM CORRECT LOCATION.
A - Sideways
B - Forward
C - Upward
PER CENT SCREEN LUMENS.
100
90
80
70
60
50
40
30
20
10
B
A
C
DRAWING #3486
EDISON LAMP WORKS
GENERAL ELECTRIC COMPANY,
HARRISON, N. J. APPROVED BY
G. H. STICKNEY. PER L. C. Porter
DATE MARCH 25, 1918
1 2 3 4 5
TENTHS OF AN INCH FROM CORRECT LOCATION.

Fig. 4

ture. To illustrate this the authors' took a motion picture lamp, focused it in a moving picture machine and measured the screen illumination. The lamp was then moved to one side in steps of 1-10″ at a time. The following results were obtained:

Filament Centered		Relative light on Screen (Lumens)	100
"	1-10″ off center	" " " " "	88.5
"	2-10″ " "	" " " " "	77.0
"	3-10″ " "	" " " " "	66.0
"	4-10″ " "	" " " " "	38.0
"	5-10″ " "	" " " " "	28.0

Similar results maintain if the filament is too high or too low. Proper centering of the light source is therefore essential to efficient projection. Very material losses also occur if the light source is placed too far ahead or too far behind its proper location with respect to the condenser. A test showed these losses to be as follows:

Filament in Focus on Shutter		Relative Light on Screen (Lumens)	100
"	1 10″ ahead of proper location	" " " " "	88
"	2/10″ " " " "	" " " " "	72.5
"	3/10″ " " " "	" " " " "	63
"	4/10″ " " " "	" " " " "	54
"	5/10″ " " " "	" " " " "	44

No spherical mirror was used in this test.

If the lamp filament is moved back of this position, an increase in screen illumination is obtained up to the point where the filament images are focused sharply on the aperture plate. Here, however, the unevenness of the screen is so great as to be objectionable. Probably a compromise between maximum evenness and maximum illumination is acceptable. Such a compromise will result if the filament is moved back about ¼″ from the point where it focuses most sharply on the shutter.

The following method may be used to locate the lamp filament:

Light the lamp and set it approximately in its operating position. That is 2″ in back of the edge of the 3½″ diameter prismatic condenser or 2½″ in back of the edge of the 4½″ prismatic condenser. Place the lamp so that the plane or broad face of the filament is parallel to the front face of the condenser.* Center the lamp with respect to both sides and up and down by adjustments provided on the machine for that purpose. When the filament is properly located in the horizontal

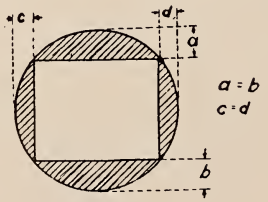


FIG. 5

*Scale drawings of this set-up are furnished by the manufacturers with instruction sheets accompanying motion picture equipment.

or vertical directions, the spot of light on the aperture plate will have equal width on each side of the aperture and also above and below the opening, (Fig. V) "c" should equal "d."

If these settings are not correct, a larger spot is necessary to cover the aperture. For example, with the spot properly set it need be but 1¼" in diameter to cover the aperture. This means a total area of 1.21 square inches, of which 0.75 square inches of light goes through the aperture and 0.46 square inches, or 36% is wasted (Fig.VI. A). If the spot is but 1-8" too low or too high, a 1 7-16" diameter spot of light is necessary to cover the aperture, which means an area of 1.35 square nches, hence practically 50% of the available light flux is wasted (Fig. VI. B). A similar effect occurs if the spot is too far to either side.

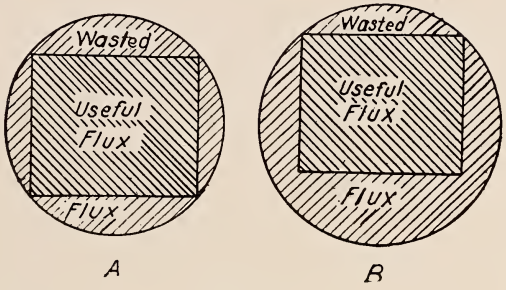


Fig. 6

By means of other adjustments the lamp can be brought closer to or moved farther away from the condenser. To determine when the lamp is the correct distance from the condenser, place one wing of the rotating shutter in front of the objective lens. An image of the lamp filament will appear on this wing. This adjustment can be more satisfactorily made if the spot of light thrown by the mirror is not on the aperture plate in addition to that projected by the condenser. The mirror should be removed or turned to one side. By moving the lamp forward and back, a point will be found where the image is sharpest. This is the correct operating position of the lamp. The appearance of the spot on the shutter wing should be as shown in Fig. VII. A.

The accurate setting of the spherical mirror is also of great importance. The mirror performs two functions: It redirects that portion of the light from the lamp filament emitted backward and adds it to that projected directly on to the condenser. By so doing increases as high as 60% in screen illumination have been obtained. Secondly, the reflected light fills up the spaces between the filament coils and thus evens up the resultant screen illumination.

After placing the center of the reflector in a horizontal plane with the lamp filament, and the center of the condenser, the reflector should be moved forward and backward by means of adjustments provided for that purpose, until the reflected spot of light on the aperture plate is the same size as that projected by the condenser, in which position the filament image on the shutter will be of maximum sharpness. The mirror is then twisted or moved slightly sideways, until the dark

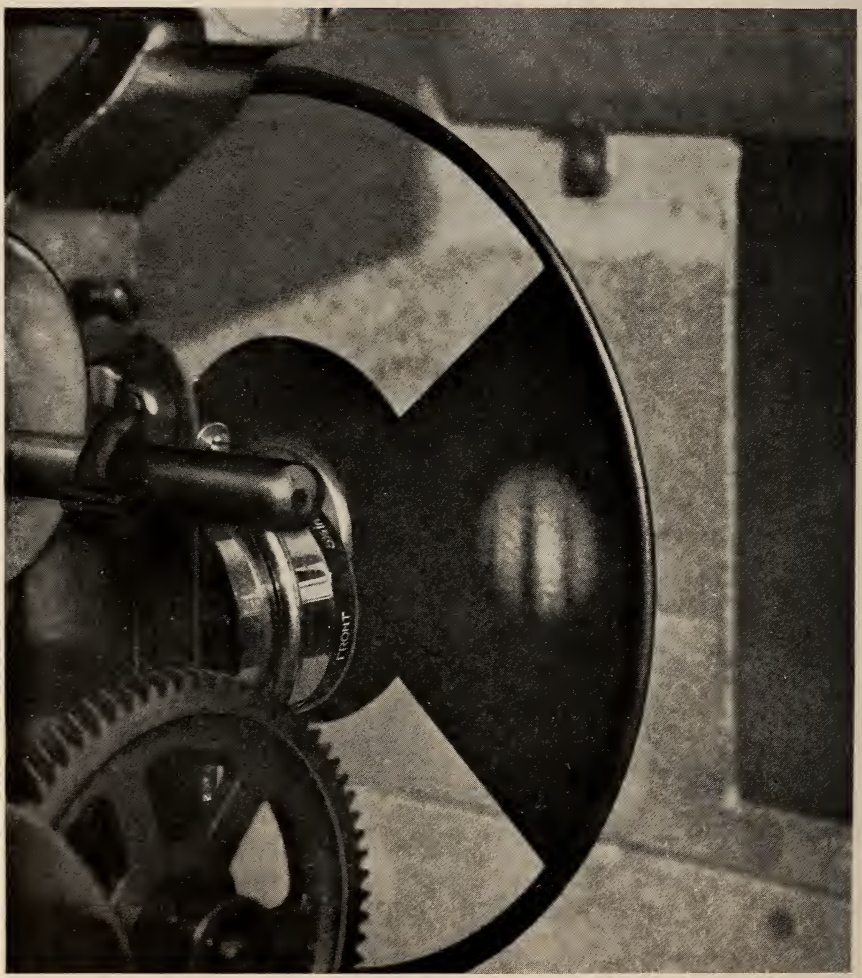


FIG. 7-A

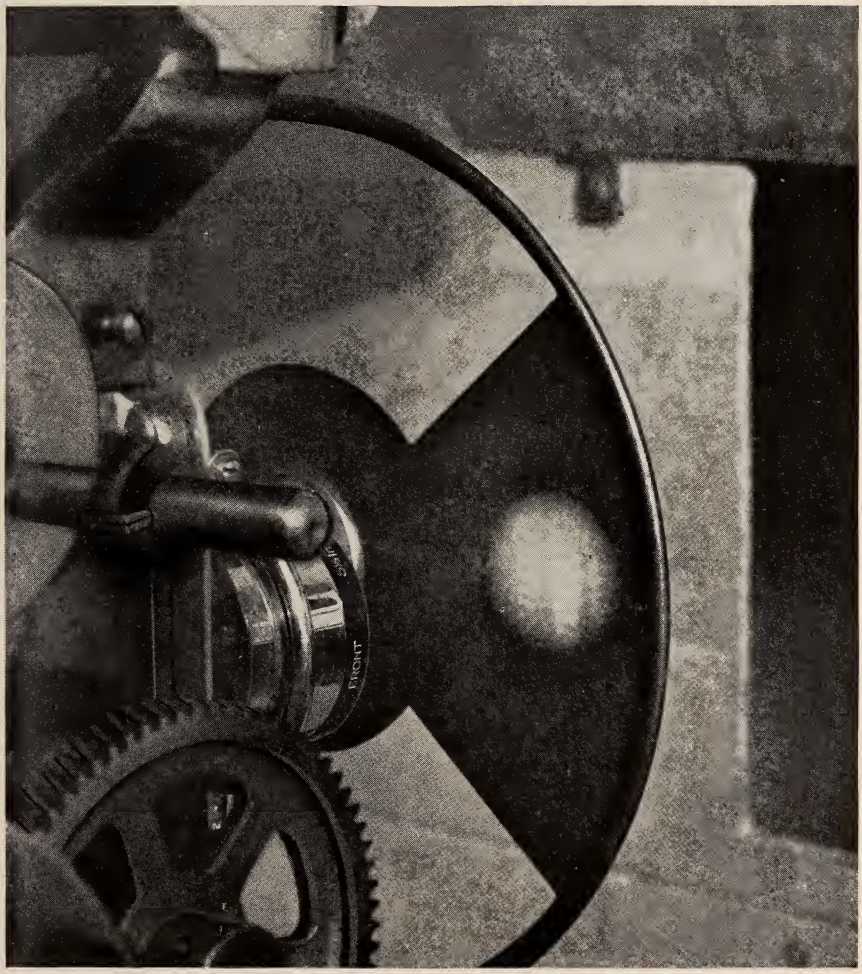


FIG. 7-B

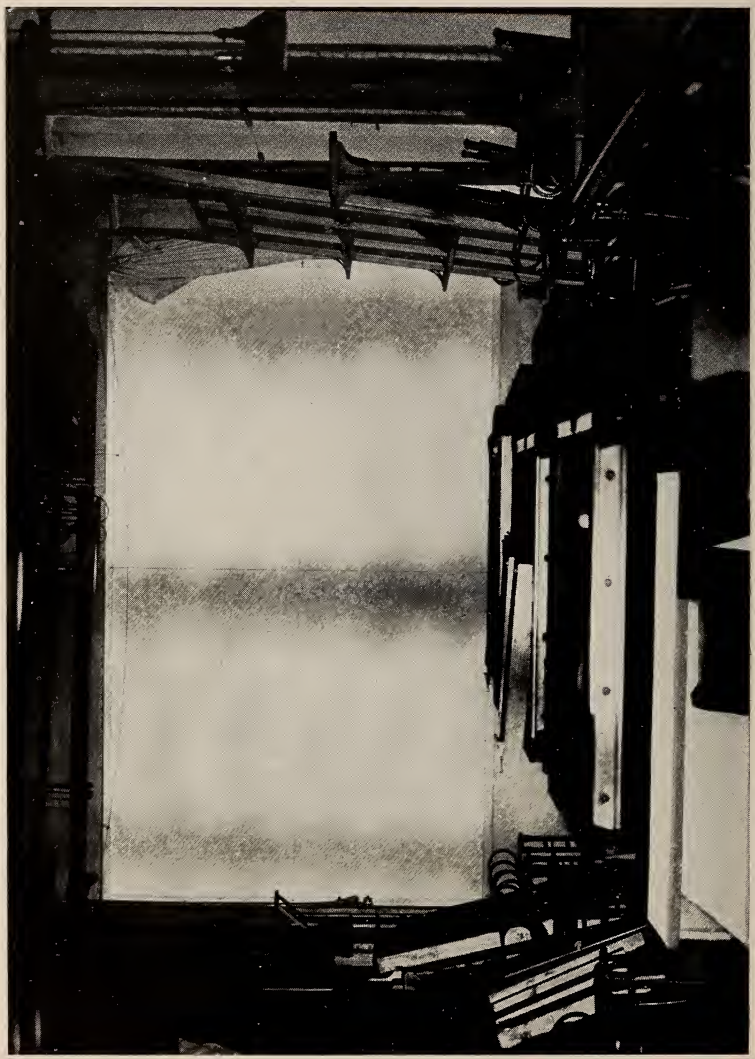


Fig. 9-a

FIG. 9-B

spaces between the filament images on the shutter are filled with the reflected light (Fig. VII. B.).

This setting is very important. If the mirror image falls on the lamp filament coils instead of between them, not only is this additional light cut off from the screen, but the life of the lamp may be slightly shortened due to overheating. Whether the mirror is properly set or not may easily be observed by quickly inserting and removing any opaque screen between the lamp and the mirror, noting the effect on the image on the shutter. If desired, the focusing of the lamp and mirror may also be accomplished on the screen instead of the shutter by removing the objective lens. The appearance of the screen with or without the mirror images properly set will then be as in Fig. IX. A. and B. This method of focusing results in slightly more even distribution of light on the screen with very little decrease in average intensity. The degree of unevenness of screen illumination, when the filament is focused on the shutter is, however, not discernible to the average eye. Tests to determine the effect on total screen illumination (neglecting the question of evenness or otherwise of distribution) of having the mirror improperly set, gave the following results:

Mirror properly located					Relative light on Screen (Lumens)				100
"	1-10"	to	one	side	"	"	"	"	88.0
"	2-10"	"	"	"	"	"	"	"	74.5
"	3-10"	"	"	"	"	"	"	"	74.0
"	4-10"	"	"	"	"	"	"	"	74.0
"	5-10"	"	"	"	"	"	"	"	74.0
"	1-10"	ahead			"	"	"	"	90.0
"	2-10"	"			"	"	"	"	81.0
"	3-10"	"			"	"	"	"	79.0
"	4-10"	"			"	"	"	"	76.0
"	5-10"	"			"	"	"	"	73.0
"	1-10"	above			"	"	"	"	84.5
"	2-10"	"			"	"	"	"	68.5
"	3-10"	"			"	"	"	"	68.0
"	4-10"	"			"	"	"	"	68.0
"	5-10"	"			"	"	"	"	68.0

A possible source of large loss is in the alignment of the condenser lens and the objective lens. It is important that the face of the condenser be parallel to the face of the projection lens, and also that the center of the two are on the same axis passing through the center of the light source and the center of the mirror. Tests were made in which the condenser was properly lined up and the screen lumens measured. The condenser was then moved to one side in steps of 1-10" also up in steps of 1-10". The results were as follows:

Condenser properly centered					Relative light on Screen (Lumens)				100
"	1-10"	to	one	side	"	"	"	"	72.5
"	2-10"	"	"	"	"	"	"	"	39.5
"	3-10"	"	"	"	"	"	"	"	24.0
"	4-10"	"	"	"	"	"	"	"	20.5
"	5-10"	"	"	"	"	"	"	"	20.0

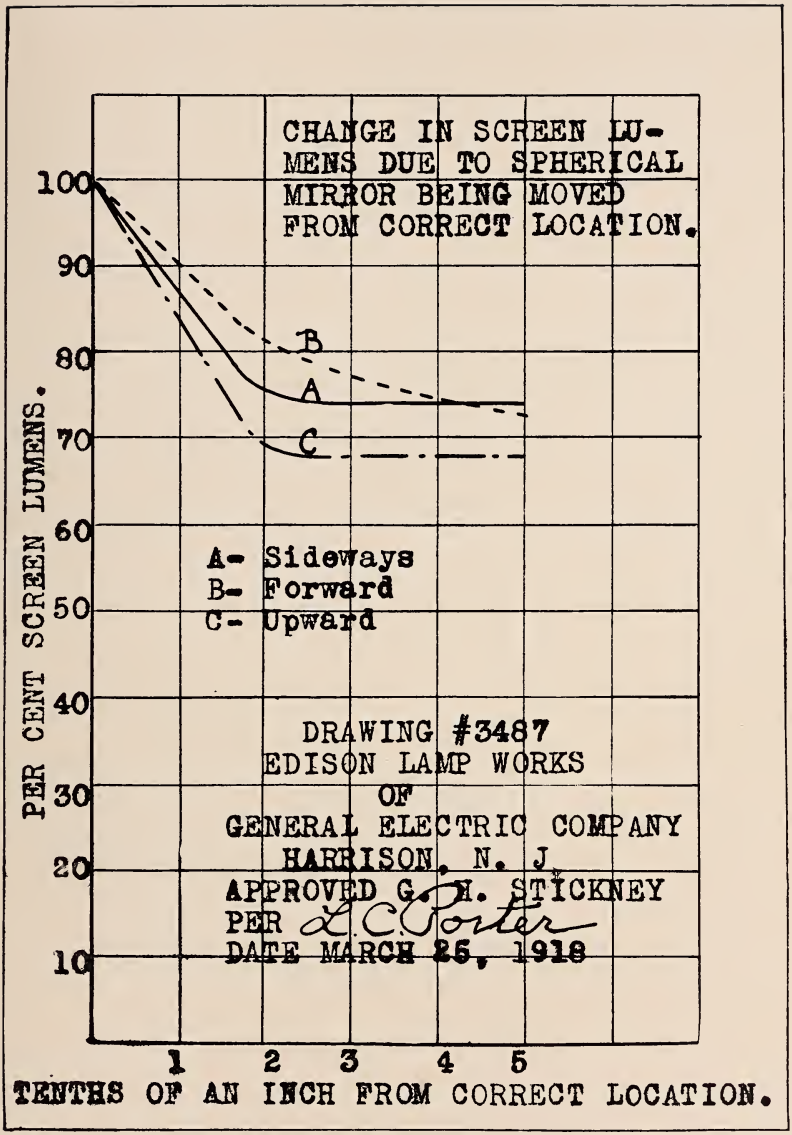

CHANGE IN SCREEN LUMENS DUE TO SPHERICAL MIRROR BEING MOVED FROM CORRECT LOCATION.
PER CENT SCREEN LUMENS.
100
90
80
70
60
50
40
30
20
10
B
A
C
A- Sideways
B- Forward
C- Upward
DRAWING #3487
EDISON LAMP WORKS
OF
GENERAL ELECTRIC COMPANY
HARRISON, N. J.
APPROVED G. M. STICKNEY
PER L. C. Porter
DATE MARCH 25, 1918
1
2
3
4
5
TENTHS OF AN INCH FROM CORRECT LOCATION.

FIG. 10

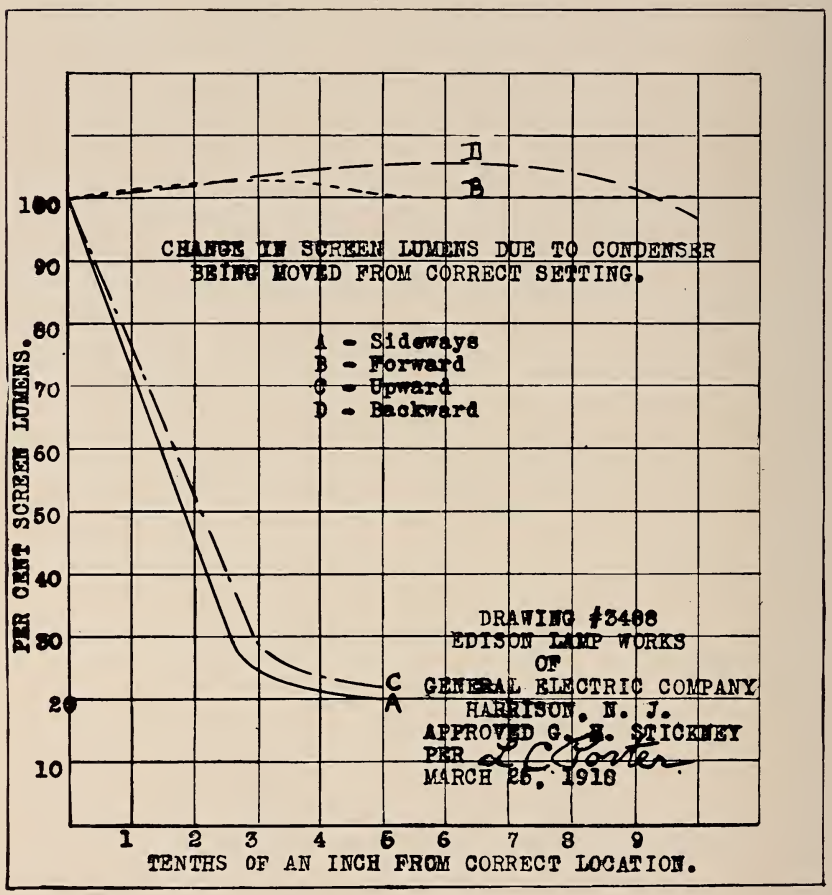

CHANGE IN SCREEN LUMENS DUE TO CONDENSER BEING MOVED FROM CORRECT SETTING.
A - Sideways
B - Forward
C - Upward
D - Backward
PER CENT SCREEN LUMENS.
100
90
80
70
60
50
40
30
20
10
1 2 3 4 5 6 7 8 9
TENTHS OF AN INCH FROM CORRECT LOCATION.
DRAWING #3488
EDISON LAMP WORKS
OF
GENERAL ELECTRIC COMPANY
HARRISON, N. J.
APPROVED G. E. STICKNEY
PER L. C. Foster
MARCH 25, 1918

Fig. 11

Condenser properly centered			Relative light on Screen (Lumens)						100
"	1-10"	up	"	"	"	"	"		88.0
"	2-10"	"	"	"	"	"	"		58.5
"	3-10"	"	"	"	"	"	"		29.0
"	4-10"	"	"	"	"	"	"		22.5
"	5-10"	"	"	"	"	"	"		22.0

A slight change in the distance between the condenser and the aperture plate has little effect, though the distance should be approximately right, *i. e.*, 5" for the 3½" diameter condenser and 6½" for the 4½" diameter. Tests on the 4½" diameter condenser showed the following variation in screen lumens obtained by moving the lens ahead of and behind its proper location:

*Condenser	6½"	from	aperture	plate	Relative	Light	on	Screen	(Lumens)	100
"	6¾"	"	"	"	"	"	"	"	"	103
"	7"	"	"	"	"	"	"	"	"	100
"	7¼"	"	"	"	"	"	"	"	"	100
"	7½"	"	"	"	"	"	"	"	"	103
"	6¼"	"	"	"	"	"	"	"	"	103
"	6"	"	"	"	"	"	"	"	"	105
"	5¾"	"	"	"	"	"	"	"	"	105
"	5½"	"	"	"	"	"	"	"	"	97

Presumably the condenser and objective lens are properly lined up at the factory and it should not be necessary to change this setting. It is well, however, to check this matter and to use great care after moving the lamp-housing sideways for lantern slide projection to get it back in the proper position before continuing the motion picture projection. There are three simple methods by which the centering of the condenser may be checked:

Let one man, provided with a piece of dark glass, place his head in the beam of light about 10 feet in front of the projector and look through the dark glass directly into the objective lens. The observer's head should be in such a position that the shadow thereof falls on the exact center of the lighted part of the motion picture screen. Looking into the objective lens through the dark glass, the corrugations on the condenser become clearly visible. An assistant should then move the condenser until these rings are concentric with and centered in the objective lens (Fig. XII. A and B.)

If one is to line up quite a number of machines, time may be saved by having a simple mechanical device made for this purpose (Fig. XIII). The device consists of a straight rod (A) pointed at each end. A section of a cone (B) of such a diameter that its center will fit snugly into the objective lens jacket after the lens tube has been removed. This cone-shaped piece also has a hole through it fitting snugly to the rod (A). A tapered rectangular piece (C) is also provided to fit snugly into the aperture plate. This piece also has a hole in it fitting rod (A) snugly. A circular plate (D) is provided with a good substantial shoulder bored to fit rod (A). These parts may be made of steel or wood, preferably steel. In using them remove the lens tube from the objective lens and insert cone (B) in the jacket. Insert rectangular

*The distance between condenser and lamp remaining fixed.

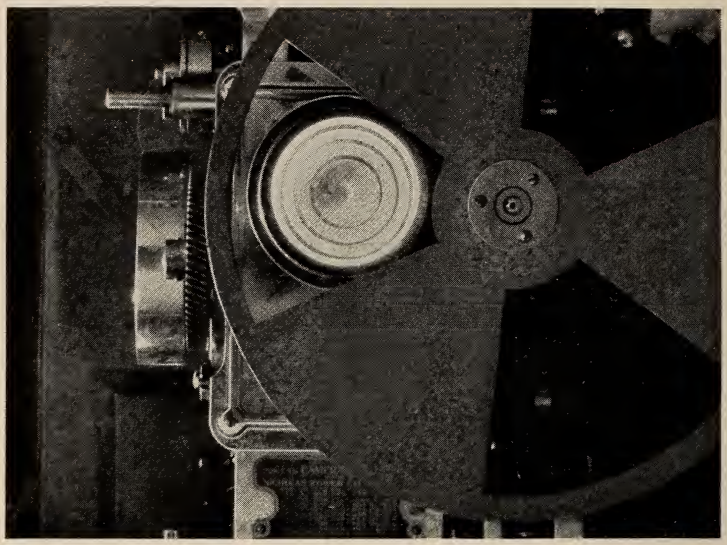


FIG. 12-A

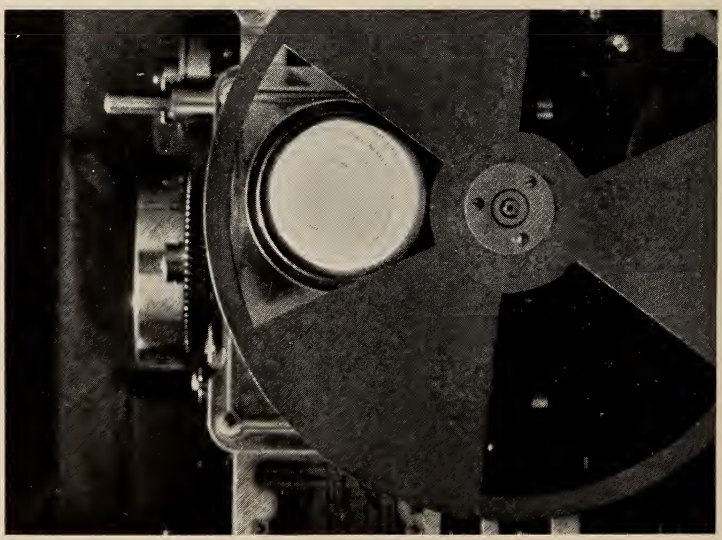


FIG. 12-B

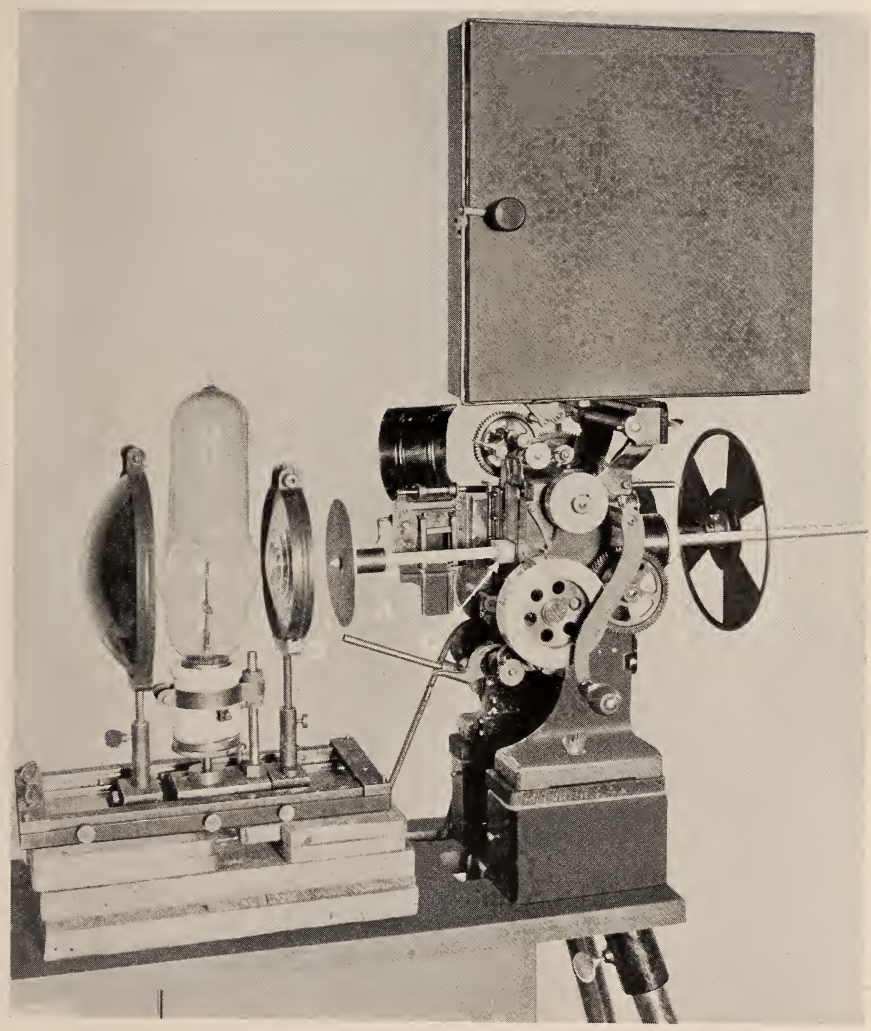


Fig. 13

block (C) in the aperture plate and pass rod (A) through them. It then becomes a simple matter to place the center of the condenser against the pointed end of the rod and thus centering it perfectly with the aperture plate and projection lens.

The plane of the condenser is made parallel to the plane of the aperture by placing disc (D) on the end of the rod and having the face of the condenser touch the disc on its entire circumference. If desired, the mirror may be similarly centered before the condenser is put in place. From the curves shown it is easy to see that if two or more of the component parts of the optical train are slightly out of line a very large loss in screen illumination may result.

The use of wide aperture projection lenses is advocated with incandescent lamps, (Fig. XIV.) The light transmission possible through 5½″ focus lenses of varying diameters is approximately in the following ratio:

Focus	Diameter	Relative Transmission
5½″	1½″	36
5½″	1¾″	49
5½″	2″	64
5½″	2¼″	82
5½″	2½″	100
5½″	2¾″	121
5½″	3″	144

The use of wide aperture projection lenses results in considerably greater gain in screen illumination with the tungsten filament lamp than with the arc. In the former, the light rays emerge diverging from the lens and practically its entire aperture is effective. On the other hand, with the arc system we have crossing rays and the outer portions of the lens are not so effective as the center in transmitting the light, *i. e.*, due to the greater distance between aperture and condenser, and therefore, narrower angle of light with the arc system, a greater proportion of the light flux is passed through the central portion of the objective lens (Fig. XV.)

The color of the light from the incandescent lamp is warmer than that of the arc and generally more pleasing on that account. There are, however, a few conditions where it is desirable to imitate closely the color of the arc. Thus, in film exchanges and studios, a customer who is an arc user may want to select his films with due reference to his own illuminant. In the film studios, where the selection is made, the pictures are generally projected a relatively short distance, 25 or 30 feet, and a fairly small-sized picture shown. Under these conditions the Mazda lamp offers more than a sufficient amount of light.

We may, therefore, sacrifice a small amount in altering its color to conform closely to that of the arc. This may be accomplished by inserting between the condenser and the aperture plate a piece of glass of the proper quality. Such glass is available as a lamp bulb, *i. e.*, there are incandescent lamps manufactured for color matching purposes with bulbs made of this very special glass. They are known as Mazda C2 lamps. A good stunt is to obtain an old, burned-out 500 watt PS-40

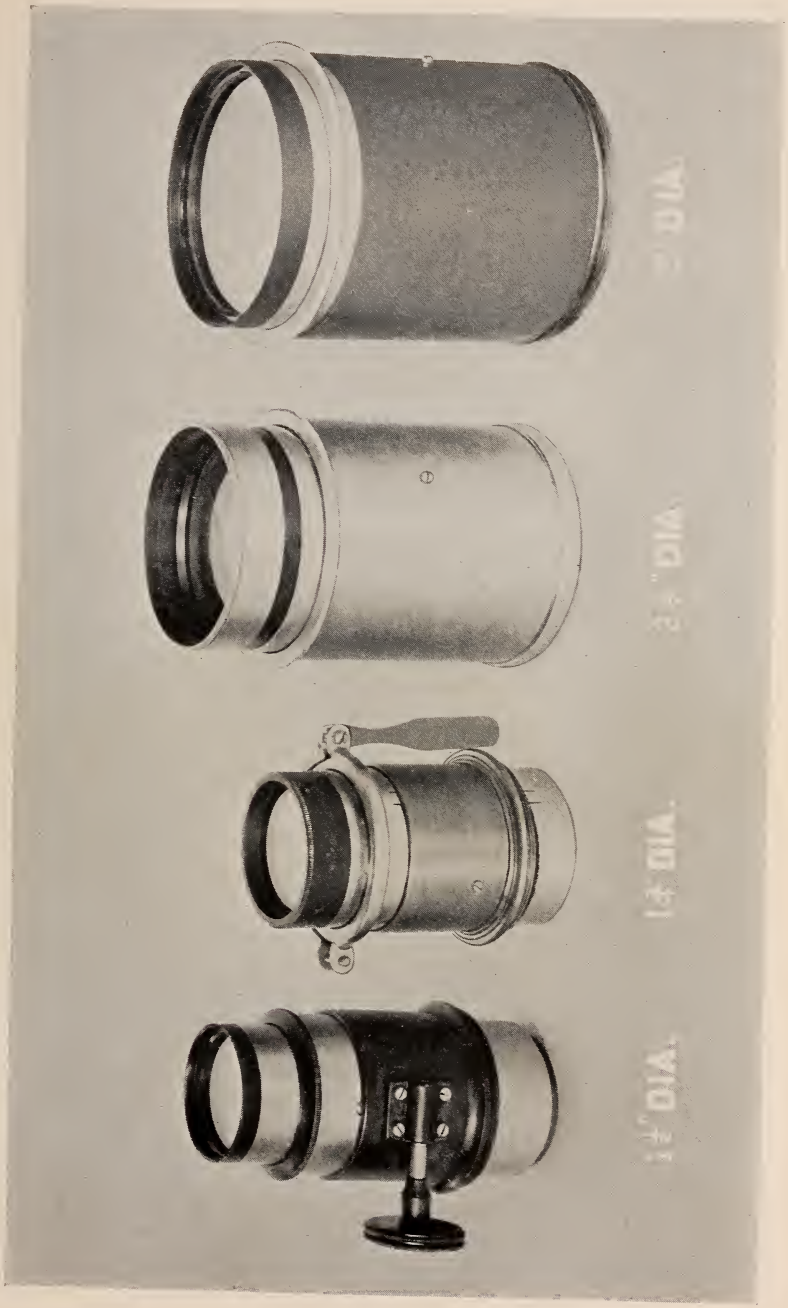


Fig. 14

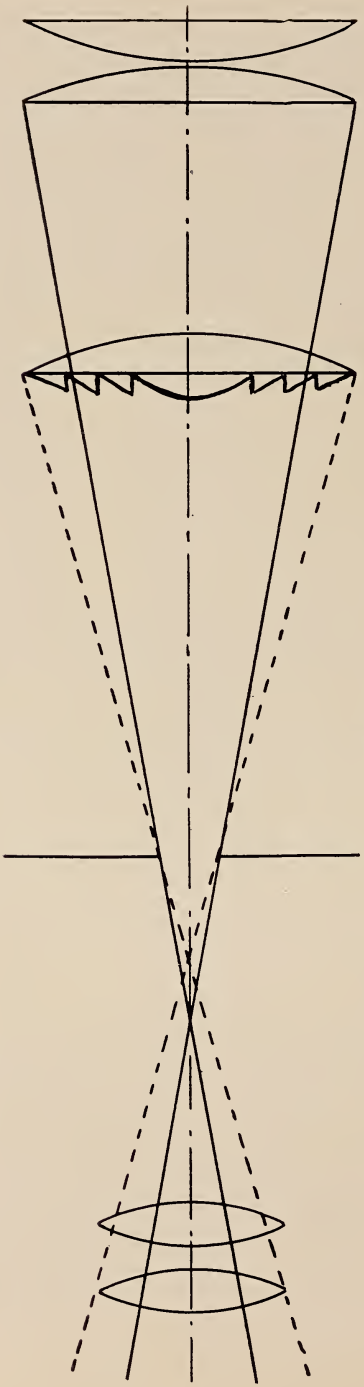


Fig. 15

bulb Mazda C2 lamp and remove a section of the bulb to place in front of the aperture of the motion picture machine. There is an old trick that may be used in removing this section of the C2 bulb. With a fine file, make a scratch on the bulb, then take a hot soldering iron, poker or any convenient pointed piece of hot metal, and place it on the filed scratch on the glass. A crack will start which will follow the hot iron wherever it is moved around the lamp bulb. In this way a nice piece of C2 glass may be easily detached from the bulb.

TESTING

Until recently it was more or less difficult to measure illumination. Photometers were expensive and considerable practice necessary to read them accurately. Now, however, there is available, at a low price, a foot candle meter which can be used to great advantage in measuring the illumination projected by various lens systems or other devices, which it is desired to compare.

In measuring screen illumination there are two methods in common use. One is to divide the actual motion picture screen into sixteen equal rectangles and measure the light intensity at the center of each of these; then average all the foot candle readings thus obtained, and multiply that average by the area (in square feet) of the screen. The result will be the total amount of light in lumens on the screen. The chief advantage of this method of measurement is that the distribution of light over the screen, *i. e.*, its relative evenness or otherwise, is measured. The disadvantage is that measuring 16 points on the screen (and for accuracy sake taking three readings at each point) is a rather lengthy process. These readings are usually taken without the film in the machine and with the rotating shutter stationary.

The total screen lumens may be obtained more quickly by placing a piece of good diffusing glass (dense opal) over the objective lens. The foot candle meter may then be mounted at any convenient, fixed distance in front of this glass and the intervening space inclosed with black cloth or paper so as to shut out all extraneous light. If many tests are to be made, it will be found convenient to build a box lined with black velvet. This box should have an opening in one and to fit snugly around the projection lens; an opening in the opposite end for the foot candle meter; and an opening at the top near the projection lens through which to view the scale of the foot candle meter. Relative emitted lumens may then be measured by one set of readings.

If it is desired to obtain actual rather than comparative values, this device should be calibrated by removing the diffusing glass and reading the 16 stations on the motion picture screen, as described above. Then read in the box with the diffusing glass in place. If, for example, it is found that there are 600 lumens on the screen and the foot candle meter in the box reads 2.00, then the constant by which the box readings should be multiplied to convert to actual lumens is 600 divided by 2 or 300.

If considerable experimental work is to be done, it will be found more convenient to use an optical bar than an actual projection machine. So far as the optical end is concerned, all of the mechanism of

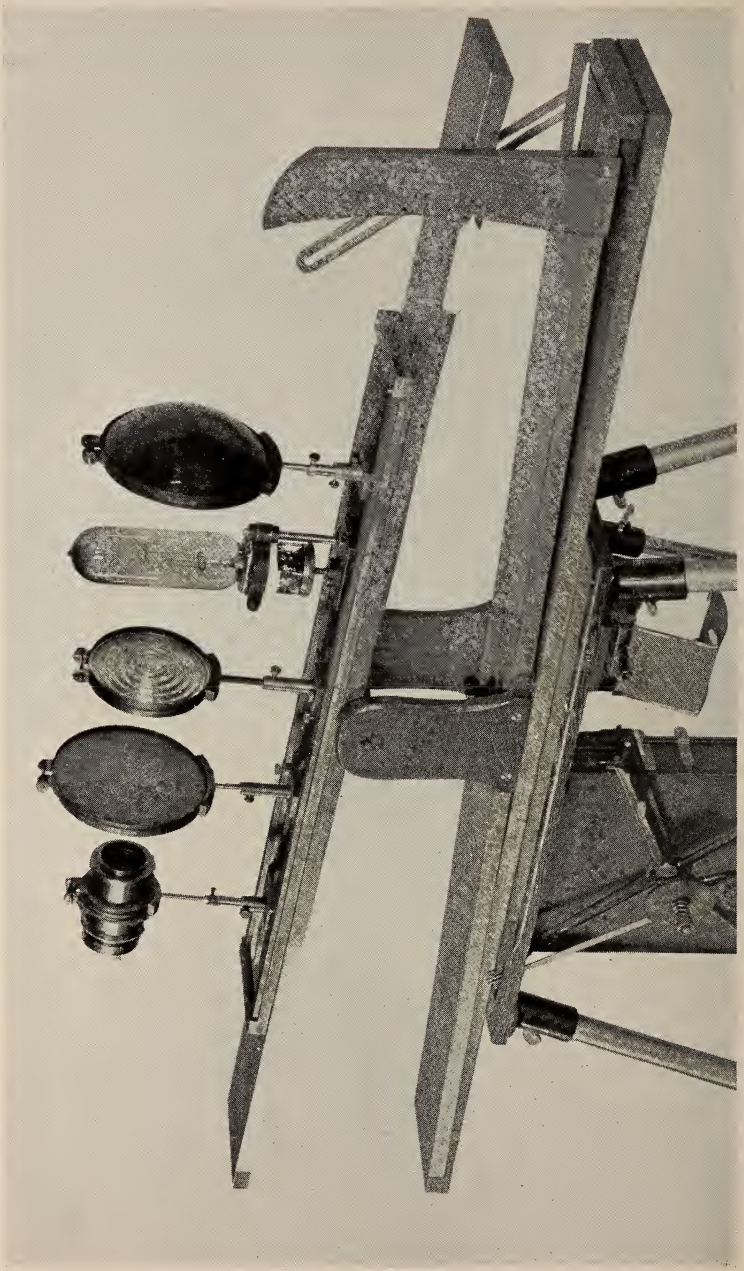


Fig. 16

the machine is unnecessary. If some means is provided for holding an objective lens, an aperture plate, condensers, lamp and mirror and varying the position of each of these elements in three directions, *i. e.*, forward and back, sideways and up and down, a most convenient testing device will result. Figure XVI shows such an optical bar. In this case the bar is mounted on a see-saw effect which may also be rotated. By this means the 16 points on the motion picture screen may be measured, leaving the foot candle meter in one position and moving the lighted field around by means of the see-saw effect. This may be calibrated and degrees or any other measured amounts of tilt and rotation marked thereon for convenience in quickly obtaining the desired settings.

The field of application for motion picture machines using Mazda lamps for light sources is large. Already the art has advanced to a point where, (taking into consideration the somewhat lower results obtained under average practical operating conditions than are possible under the best conditions) incandescent motion picture lamps will successfully replace any A. C. arc on 25 cycle current, 50 ampere A. C. arcs on alternating current of 60 cycles and above, also 25 ampere D.C. arcs. In other words, 12-foot pictures projected on a plain, white screen, or 16-foot pictures on metallic or mirror screens, up to throws of 100 feet. By such a replacement better pictures are secured at a lower operating cost.

The Society of Motion Picture Engineers has, among its members, many men actively engaged in the manufacture of large as well as small or portable motion picture machines. There is a wonderful field open to these gentlemen. The educational possibilities of the motion picture machine are enormous. It is the authors' belief that some day the house machine, and those for use by salesmen, etc., will vastly outnumber its larger prototype, now so common in the motion picture theatre. The two factors which will contribute most to this accomplishment are, Safety and Simplicity. The use of the tungsten filament lamp for a light source secures the latter and contributes largely toward the former. After Simplicity and Safety we desire Excellence of screen results.

It is hoped that a careful study of the data presented above will be of assistance to you manufacturers in producing the highest grade machines, and to the users of these machines in getting the best out of them, thereby jointly obtaining excellent pictures.

The lamp manufacturers are with you from start to finish, both in the interest of science, and the advance of education, as well as from the commercial standpoint. Our various engineering departments are in a position to assist you in your developmental work, and we shall be glad to have you call for such assistance at any time.

In conclusion, the authors wish to thank Mr. J. Force of the Laboratory and Mr. E. F. Carrington of the Photographic Department of the Edison Lamp Works for their assistance in obtaining and preparing the data presented above.

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

No. 7

MEETING OF NOVEMBER 18-20, 1918

CLEVELAND

TRANSACTIONS

OF THE

SOCIETY OF MOTION PICTURE ENGINEERS

MEETING OF NOVEMBER 18-20, 1918

CLEVELAND

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OCTOBER, 1918

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SOCIETY OF MOTION PICTURE ENGINEERS

Membership in the Society of Motion Picture Engineers stands for unselfish service to the Industry. Applications for membership are by invitation and endorsement. All checks should be made payable to the Society of Motion Picture Engineers.

All receipts are expended directly to promote the objects of the Society and the interests of its members. There are no salaries or emoluments of any kind.

The following are extracts from the By-Laws:

The objects of the Society are: The advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the mechanisms and practices employed therein and the maintenance of a high professional standing among its members.

An Active Member is one who is actually engaged in designing, developing or manufacturing materials, mechanisms or processes used in this or allied arts, or who is interested directly in the art.

Any person of good character may be a member in any or all classes to which he is eligible.

Prospective members shall be proposed in writing by at least one member in good standing, and may be elected only by the unanimous vote of the Board of Governors.

All applications for membership or transfers in class shall be made on blank forms provided for the purpose, and shall be accompanied by the required fee.

The entrance fee for all members shall be twenty-five dollars ($25.00). The annual dues shall be ten dollars ($10.00), payable in advance before the annual meeting (October) of each year. That is, the total fee for the first year, which includes the entrance fees and first annual dues, is $35.00 for all member.

PRESIDENT'S ADDRESS

Cleveland, October 21, 1918.

Gentlemen:

This meeting of the Society of Motion Picture Engineers is an anniversary of two successful years, and begins a third which holds a promise of still greater usefulness and solidity.

We have preserved our identity and individuality on the sound theory that we are strong enough to go it alone, and have steered our little craft so far in safety, and to a position of credit and respect in the industry.

Unselfish service has been our watchword from the first, and if this source of inherent power is guarded with unceasing jealousy, I believe we may confidently look forward to a stable future of still greater usefulness, and an enlargement of our Society into an international organization. Such an attainment is perfectly feasible, for the basis of our industry, the picture ribbon, is standard the world over.

The papers read before this Society represent an accumulation of specialized knowledge, prepared by men expert on the particular subject of the discourse, and with selfish interest left out. And printing these papers puts them into convenient form to be consulted and studied at leisure, and they are already much in demand.

The preparation of these papers, the unselfish contribution of busy men of affairs and always at a personal sacrifice, is particularly a notable labor of love in these strenuous war times, and it seems therefore particularly opportune at this time that I should express the appreciation of the Society for their contribution of these valuable papers.

I think all the Transactions should be collated and bound into a single volume, for these papers are invaluable. The information contained therein can be found in no other book anywhere. Not only will our own members want these bound copies, but I believe others will also, and provision for making them readily available should be arranged.

As we go on, this wealth of specialized information will be augmented and be more and more attractive to those who seek answers to their motion picture problems. And there are many subjects which have not yet received our attention because of lack of time or opportunity for full consideration of the subjects. For example, a standard unit screen surface by which we can compare picture screen surfaces. That proposed at one of our meetings, namely, oxide of magnesia, was laid over for action later. I think we might profitably take it up at this meeting.

A troublesome subject badly needing standardization is film tinting for the different colors. The present haphazard practice leaves the lighting engineer and the machine designer nothing but a compromise course, and the projectionist can do but little more than ignore the subject entirely.

Red should not cut off 79% of the light, orange 62% and blue 40% as is now very, very frequently the case. Tinting for color does not need to be dense, but as long as some studios tint heavy and some light

for the same color, the engineer cannot make the best machine attainable. Standardization of tint will change all this favorably.

Another very fruitful source of investigation is the excessive loss of light in the optical system of our projectors. In no other lighting system are such losses to be found. In searchlight work 60 to 90% efficiency is common, while in motion picture projectors, efficiencies of less than 5% are the rule. I think you will agree with me that this is a promising field of research. The beam of light in our picture machines is only a parallel searchlight beam somewhat more concentrated, and intercepted by a stencil which causes shadows, half-tones and high lights on the screen to produce a picture in monochrome.

Perhaps no other single object has more warrant for intensive study by our Society than this one of light conservation for it has many and rather wide reaching effects. Not only will it have a bearing on education by making this universal printing press available in more remote places than is possible now, but it will materially reduce the fire risk by reduction in the heat attendant on the production of light.

In the arc lamp the light falls off directly as the current, while the heat as the square. Therefore, if the current and therefore the light can be reduced by four the heat will be decreased by sixteen, certainly an object worthy of the attention of any of our engineers.

These are but suggestions, for there are many subjects needing our attention. The laboratory of the producers has not yet given us the membership greatly to be desired in our discussion of problems involving the art where production touches elbows with reproduction.

When all these things have received deserved attention, our work throughout the world will be more and more felt, for it is not with cold reasons that we may judge of the possibilities of our industry when standardized.

The motion picture is a new teacher speaking to every man in his own tongue, including those who cannot read printed characters at all. It is also a new art expression. For centuries we have had the art of form, architecture, sculpture, drawing; the art of sound, music and singing; now we have the art of motion, and its limitless possibilities as an instrument of expression are but just beginning to attract the artist. The industry has brought forth a new type of artist. Let us quickly get a standardized medium for this new artist.

SOCIETY HISTORY

Our Society has now definitely reached the growth where its influence is sought. This enviable state is gratifying to me, personally, as you will see if you will permit me to recount the history of its birth.

Every national organization of the motion picture industry, by whatever name, has had its Committee on Standards. I was first elected to membership on that Committee of the Motion Picture Board of Trade. We met once, then "blewey." I was next elected on a similar Committee of the present National body, and on call made a trip from Washington to New York to find not a single other member or officer present, with the exception of the secretary of this Com-

mittee who was also Secretary of the National Association, in whose office we were supposed to meet. At my insistence he phoned members nearby, but without result. "Blewey" again.

On the way home that afternoon I fidgeted in my chair, fussed over conditions which made for such fruitless efforts, and determined I would put my personal standing in the industry to the risky test of inviting engineers to come to Washington for the purpose of organizing a Society of Motion Picture Engineers, on my own responsibility. I am terrified even now every time I think of the chagrin I would have felt had the call gone unacknowledged.

But a most gratifying response rewarded my anxious wait on the fateful day, for Mr. Don J. Bell came down from Chicago, Messrs. Willett and Westcott from Boston; Cromelin, Cannock, Gillett and Miles from New York. These gentlemen with Mr. Brockett and myself formed a very substantial nucleus indeed. We adopted a constitution and by-laws, and adjourned to meet in New York in October after incorporation should be completed.

And right here was where our little bark first struck rough water. Twenty-four hours before this New York meeting our Secretary sent out unauthorized notices that the meeting was adjourned three months to meet in Atlantic City. Happily this calamity was averted when a considerable number of telegrams, hastily dispatched, collected a very substantial gathering, and permanent officers and directors were elected. This was indeed a critical time. I remember that a gentleman met me in the lobby when the future of the Society was trembling in the balance, and introducing himself, said he came from Pittsburgh with another gentleman both of whom would like to join the Society if it was going to amount to anything. I told him it was going to amount to a-plenty even if I had to knock down and drag out all obstructionists. These two gentlemen, Mr. Wible and Mr. Campe, have proved stalwart workers, and have added materially indeed to the stability of our organization, as you all know.

Our next meeting, Atlantic City, marked the beginning of our real purpose—namely, the dissemination of specialized data relating to our art; and the next meeting held in Chicago, added a set of unanimously-adopted standards. This data and these standards have already been in considerable and growing demand. Each copy of our Transactions is valuable, but I think all of us will agree that our last printed volume is not only a very valuable publication but one of the finest pieces of printed matter ever publicly distributed.

Our Society is now a well-knit body, and certainly the time has come when much of the arduous work which necessarily during the heading months of such a body devolved upon the office of the President, can to advantage be delegated, as is demonstrated by the excellent work of the Papers Committee.

If you will permit me to speak from this experience as your Presiding Officer I should like to make a few recommendations, two at least, that I think worthy to be adopted at once. First, that the officers who pass on expense vouchers and sign checks therefor, whether the treasurer and president, or a vice-president, should, for convenience and efficiency, reside in the same city. Second, that to the duties of the

Papers Committee be added responsibility of the publication of the Transactions, certainly so after the work now in hand is completed and out of the way.

As I said at the Rochester meeting, I am not a candidate for a third Presidential term. But before relinquishing my opportunity to speak from the chair, I should like to confess to two errors of personal judgment. The first was the effort to prepare at the request of the Federal Government, a camera specification for war work, in conjunction with Don Bell and Carl Gregory. It wasn't wholly a success because these camera authorities couldn't agree. This should have been a warning to me that the request of the Underwriters Laboratories that we adopt an alleged ideal specification for a projecting machine was unlikely of approval by makers of diverse models, which was my second mistake.

It did one thing, however, well worth while. It clarified the atmosphere and made more distinct to me and perhaps to others of us, the objects for which this Society was organized and even more strikingly the things for which it is *not* organized.

For example, the Society of Motion Picture Engineers is not a judicial body to settle controversies between conflicting interests or to promulgate recommendations which make for class-discrimination. If our Society ever degenerates into a contest between factions each trying to use the Society for personal advantage, then our usefulness is ended and our organization will soon break up as others in the motion picture industry have already done.

What we *did* organize for was to set our official seal on standards generally recognized as standards; and second, and perhaps best of all, to put into permanent form for world-wide distribution, the specialized knowledge which our members, experts in their particular line, are so unselfishly furnishing for this purpose. And while the official stamping of generally acknowledged standards is a necessary duty, for myself I have found the most interest in our meetings has come from the valuable papers read and printed, and I don't believe the limited time of our meetings can be spent in a more worth-while manner.

And it is by the printed copies of these papers that we shall be remembered, for they will doubtless find their way not only into the hands of our members and others of our own industry but into libraries generally. Perhaps nothing is more to be desired or would add more to our prestige or usefulness.

And there is a wonderful collection of data already collated. Do you want to know the percentage of loss of light by reason of the tinting of films—it is in the Transactions. Do you want to know the distortion error due to angular projection—it is in the book! Do you want to know the source of loss of light at various points in the optical system—it is in your own printed copy. Do you want to know the cause of the stroboscopic effect of shutters—it is in the booklet sent our members. Do you want to know the proper current density for carbon arcs—reach for the bound volume. Do you want to know the advantages and disadvantages of various electric current devices—it is in the unselfish report of that Committee.

Gentlemen, I thank you for hearing me through, I have a fatherly feeling for this Society.

C. Francis Jenkins.

STANDARDIZATION OF THE MOTION PICTURE INDUSTRY, AND THE IDEAL STUDIO

By John W. Allison

Owing to the tremendous growth of the industry from the beginning, due not only to its novelty, but primarily to its human interest, the Pioneer Producers had their hands full in trying to supply the demand for motion pictures which was increasing by leaps and bounds from day to day, so that it was impossible to stop and give thought to the systematizing or standardization of production. The public found a new source of entertainment, and the public would not be denied. It *would* have its fill, and while the *novelty* of this *eighth power of the world* was upon them, they gave no thought to the *quality*. What they wanted was *motion pictures galore*, and the wise producers gave them what they wanted, and waxed rich thereon. They had found big profits on small investments, so they thought: Why not let well enough alone?

When the big financial interests of the country saw the *bank accounts* of these pioneer producers climbing up into the *hundreds of thousands*, they thought they were *missing something good*, so they got into the game, and today the *motion picture industry* stands among the foremost industries of the nation, and those engaged in the industry are higher paid per capita than in most any industry in the world, notwithstanding which, most producers are able to make handsome profits on the money invested. And this on top of the fact that there is probably more money wasted through lack of proper standardization in the industry, than any business in the world.

Now I am not going to talk on the *art* or *stage-craft* side of the industry at all. I know nothing about it. The industry at large is in the hands of the most successful dramatic producers of the day, men who have catered to the amusement of the public for years. They have gathered around them the most popular artists for their casts, and the most able directors to stage their stories, together with the necessary help. All of which they *know how to select*, for they have been employing people in these lines for years. The motion picture industry, however, calls for a new class of help with which many are not so familiar, I refer to the *photographic department*, on whose efficiency *really depends the final result*, for if *they* don't make good, the answer is *failure*. So, it is on the *standardization* of the *photographic department* that I am going to speak, and as the results depend solely on *proper exposure*, this will be my chief topic. Right here I want to say that no system of standardization can be carried out without thoroughly competent and well paid help.

Standardization of an industry should begin at the beginning, and as the producers of motion picture film have a standardized product to start with, *i. e.*, the film, the first thing for the producer to standardize is the exposure, and this can only be done by standardizing the conditions under which the film is exposed. Of course, I refer to work in the studio.

Messrs. Hurter & Driffield, of England, whose research work in the photographic field is recognized throughout the world, put great stress on the necessity of securing a technically perfect negative. Let us quote a few words from their little book on "Photo-Chemical Investigations and Methods of Speed Determination:"

While we quite realize that the artist will always produce the best *picture*, we contend that the scientist will produce the best *negative*. The photographer, therefore, who combines scientific method with artistic skill is in the best possible position to produce good work.

The truthful representation of light and shade involves the production of a technically perfect negative, *i. e.*, one in which the capacities of its graduations are proportional to the light reflected by those parts of the original object which they represent. Our investigations show that such a relationship does exist, but only when a plate has received what we term a *correct exposure*.

While many photographers attach very little importance to accuracy in exposure, and maintain that errors may be readily corrected by suitable modifications in the composition of the developer, we have always strongly insisted that a correct exposure is an essential foundation if we aim to procure a technically perfect negative. It must be clearly understood, however, that, by a correct exposure we do not imply that there is necessarily one exposure, and one only, which will yield a negative answering to our definition. Fortunately most plates admit of some latitude in this respect.

Our contention is that the latent image, false in its gradations, cannot, by modifications in the constitutions of the developer, be made to yield a visible image true in its gradations. The practice of photography, by methods of scientific predetermination, imperatively demands a correct exposure as a fundamental condition."

The standardization of the exposure so that at all times every foot of film exposed in the studio will be uniform in density will do away with the necessity of variations of timing on the printer, and eliminate the uncertainty of the finished result, also one can predetermine the screen results when toning or dying is resorted to.

I have been working on an indirect system of studio lighting to standardize the exposure, in which the volume of indirect light is governed by the cubical area to be lighted, and in addition to which the light effects are secured by the use of a few diffused direct light units. In this way the photographer can exercise his artistic ability with the assurance of a perfectly exposed negative resulting. Of course, studio conditions will have to be somewhat changed from the present methods of working, but the certainty of the results will warrant the expense.

Ninety percent of the time we spend in indirect or reflected light. Such being the case, why should we not make our photographs in the conditions under which we normally live. The Eskimo is a specimen of a human being who spends most of his life under direct light. Now, who would want to be photographed to look like an Eskimo?

To my mind the use of undiffused direct light in the studio is a great mistake. Besides causing terrific eye strain for those working under it, it is responsible for the chalk and lamp black effects so often seen upon

the screen, which is the result of overexposing the high lights and underexposing the shadows. No laboratory man, however efficient, can make a good negative from a film exposed under these conditions.

Under present working conditions, with every camera man turning in film made under differing conditions of lighting and exposure, it is really remarkable that the laboratories get as good results as they do. Therefore, can you imagine what it would mean if the conditions were such that the director and camera man absolutely *knew* that the exposure would be correct, and the laboratory man *knew* that the film will require exactly so many minutes in the *standard developer*, at a *standard degree of temperature*, to produce a technically perfect negative?

The question will arise, does this method of standardizing exposure rob the camera man of any of his honors and glory? The answer is—No, for it makes him absolutely sure of his results, and permits him to use his ingenuity to the limit, even to securing the most delicate of lighting effects.

The use of combined daylight and artificial light is bad practice, as the actinic value of daylight is changing every hour of the day and month of the year. The immense glass studios at present in use are unbearably hot in summer and excessively costly to heat in winter. A cloud passing over the sun during a daylight exposure in the studio is only one of the disadvantages of working under glass. A scene partially made in one day and having to be matched up on another day (or even from morning to afternoon) is almost an impossibility. Of artificial light used in conjunction with daylight, at least 50% of the light is lost through the inability to confine the light to the area required. Light is like sound. It goes on forever, and unless confined where wanted it diffuses with the daylight and its value is lost.

The ideal studio, to my mind, would be one made up of separate rooms for settings, the partitions of which could be removed as required, with all the light equipment handled from above, both indirect and diffused direct. The amount of saving in floor space over present day method being no small item of convenience and saving, because we are paying for space by the square foot. With these separate rooms for the settings, each director, his staff and company are working on a picture entirely isolated from those working on other sets, they would be free from noises and distracting conditions, to which they are subjected under present methods. The lights for each set being controlled by switches in the settings where the director could turn them on or off as needed, would be a great saving of time often lost while waiting for the assistant electrician to do this for him, and during rehearsals only as much light as is really needed would be thrown on the setting.

So much for the standardization of the exposure.

The real need of the industry is *team work*, not grand stand *play*. No one man can know it all nor take the credit for all. The book of the motion picture has three chapters: Literature, Art and Science. Let each one to his own. When the camera starts working and making the record, all that literature and art could do has been done, and unless the exposure is right, neither literature, art nor the science of chemistry can make possible an acceptable result on the screen. And strange

as it may seem, the failure of many fine stories, acted by fine casts, is due to poor photography, for which there is no adequate excuse, as photography is an exact science, the results of which can be predetermined with as much certainty as the weaving of cloth. Exterior exposure can be determined by the use of light measuring instruments, so that they will require the same treatment in the laboratory as pertains to those made in the studio.

The standardization must also embrace the use of *rational color-combinations* for the settings. Many color-combinations beautiful to the eye are wholly unfit for photography, because the film will not record them as the eye sees them. This is a subject requiring the greatest study, particularly in studios where both the arc-lights and mercury vapor lights are used, as the spectral quality of the two lights is entirely different. The film is capable of recording a certain part of the spectrum, and what it registers depends upon the source of light. The nearer you get to daylight with your artificial lights, the better the results you get on the film, and by reason of the limited region of the spectrum to which ordinary negative film is sensitive, the fewer colors used in the studio, the better. Reds, dark browns, greens and yellows, should not be used, except where very heavy backgrounds are wanted for visions, etc., as these colors have no effect on the film. Blank-white should be avoided, as it tends to chalkiness, and hard results. Combinations of light-reflecting colors,to which the film is sensitive in some degree should be used to secure harmonious results, and all combinations that give extreme contrasts on the film should be avoided, as they jar the senses, and detract from the full enjoyment of the story.

Trick-photography must be used sparingly, it is apt to detract from the story, and is no longer a novelty. The smoother the presentation of the story, the more enjoyable it will be.

In the making of *close-ups*, great care should be taken not to get them on too large a scale. There is nothing so ludicrous as a head about four times the natural size.

Regarding the Laboratory

The laboratory must be in charge of an *expert photographic chemist* of wide experience, not merely a good darkroom man, for should any trouble develop in the processes, you want a man who can put his finger on the cause *immediately*.

One of the chief requisites of the laboratory is a *research department*, where all film should be tested out immediately upon its receipt from the factory, and a record kept of all tests. In order to do this under proper conditions, a small studio must be built embodying the identical conditions as prevail in the main studios, as to amount of light per cubical area, etc. Here all tests should be made for studio practice, such as speed of film, color-combinations for settings, tests of new subjects for the casts, etc.

The research department should make all tests of new chemicals and processes and lay out the after treatment of the positive film, such as toning and dying. It should also test the solutions of the laboratory workrooms daily, and keep them up to specified requirements.

The research laboratory should be thoroughly equipped with the proper instruments to make these tests, and a complete photographic library installed as far as modern practice is concerned. Here also should be received and kept on file all pamphlets issued by the different manufacturers, particularly the pamphlets issued from time to time by the *Research Department of the Eastman Kodak Co.*, which are the most valuable contributions to photographic literature published in this country. Here also should be found the *British Journal of Photography*, and their *Annual Almanac*, and any other technical papers of interest to the trade.

We will assume that the laboratory workrooms are equipped with the most modern and improved fixtures to carry on the work, so we will proceed to outline what we know should be done.

The first thing your laboratory chief should do is to have a chemical analysis made of the water supply. This analysis should be submitted to the manufacturers of the film, to find out if it is suitable for obtaining the best results with the formulae supplied for the film. If the film makers find that an adjustment of the formulae is necessary, they will so advise, and their advice should be followed to the letter. *They know what treatment their* film requires, and it stands to reason that they are not going to recommend any developer for their film, but the one they know is best. With this specified developer, they will give a *standard of time and temperature* for the development, or what is known as a *factor* for the formulae to get the best results, and if the instructions have been carefully carried out, the results will be uniform at all times. Of course, as the development of the film shows up the developer by the depositing of bromide, which takes place in the conversion of the exposed silver-bromide into the metallic silver, which forms the image, the *factor* will change, and this change should be noted day by day for the work in hand.

As the ingredients of the developing solutions have a tendency to settle, thus making the solutions of varying strength throughout, a system of syphoning, or pumping must be installed which will keep moving the solution from the bottom of the tank to the top. This will keep the strength of the bath uniform.

The developing factor of each bath must be checked up daily, by the development of a piece of standard exposure film. This must be done by the research staff, and a notation of the day's factor attached to the tank. This will govern the time required for development at the existing strength of the bath. As soon as the bath shows the slightest indication of actual exhaustion, it should be discarded at once, the tanks thoroughly cleaned, and a new bath prepared.

The present methods of washing and drying in conditioned air are, to my mind, perfected to a very high degree. This department has been given the proper care and attention, because of the *absolute necessity* for keeping the films perfectly free from dust.

Makeup

As the film records values about like the eye sees them when viewed through a medium blue glass, the dressing-rooms should be lighted with *blue glass bulbs* and the artists put on their makeup under these

light conditions. If the makeup looks right in this blue light, it will be nearly right for the studio, particularly if the studio be equipped with the mercury-vapor tubes. The research department should test out the screen effects of all makeups, for the different types and complexions. This must be done in the miniature studio. The individual makeups should be indicated, and under no circumstances should the artists be allowed to vary from the makeups decided upon for their use. Theatrical artists are so used to the makeup for stage lighting, that it is hard to make them see the necessity for a change when working under the studio lights, but once they get a chance for comparison on the screen, there should be no trouble in getting them to adopt the makeup suitable for the lighting conditions of the studio.

A Few Suggestions

In most of the studio photography, even today, the tendency is either to flat lighting, or to the other extreme of violent contrasts, in the one case making the human face look as flat as a map, and in the other showing chalk-white highlights with absolutely no details in the shadows. Imagine how many photographs the Fifth Avenue Portrait Photographer would sell if he portrayed his subjects in this manner. A careful examination of the show cases of our highest paid portraitists will show the kind of work the critical public demands, and in none of these will you find the class of work referred to above.

The motion pictures still are atrocious in most cases, when they should really be works of art, for what with the care and attention paid to the settings and costuming, every opportunity is afforded to produce masterpieces of the photographic art, and as these pictures are for use as lobby displays to draw the public's attention to the films, no expense should be spared to make them attractive. The same thing applies to the lantern slides, generally of indifferent quality, used for announcements of forthcoming attractions. With so much money spent on elaborate productions, to me it seems bad policy to be penurious in these items.

Some producers have enhanced the attractiveness of their films by the artistry of their titles which are a most welcome improvement over the former stereotyped white-lettered titles, which were not only distracting but very hard on the eyes of the audience. Titles should be modulated in their tones, and be diaphragmed on to the creen, not *shot* on, as this results in shock.

With the foregoing suggestions I must close, summing up as follows:

First: That as the ultimate success of the picture depends primarily upon a perfect exposure, *the conditions under which the exposure is made must be standardized.*

Second: That my reason for insisting upon the necessity of a *time and temperature* system of development, is not only because it is the *only method* by which you can *actually standardize development*, but to do away as far as possible with the *human factor*. The constant changes in the personnel of the developing staff, where the old method of development by examination is in use, makes it almost impossible to get uniform results, and this applies particularly under present labor conditions, when it seems impossible to keep an operating staff

intact, owing to so many being called to the colors, and others leaving to take up positions made unusually remunerative by the needs of war.

Third: That the proper use of makeup, and the use of color combinations must be given more attention in order to get the best results.

Finally: That the above results can only be accomplished by the installation of a research department composed of thoroughly competent help, and then only if their instructions are followed out.

Discussion

In answer to Mr. Burrow's question, as to whether the blue glass bulb referred to was the regular daylight lamp or one of more dense coloring, Mr. Corey said that the blue glass bulb now on the market was referred to, in connection with photography under light that resembled daylight.

Mr. Mayer said the suggestion in Mr. Allison's paper was a combination color filter for viewing the make up and sets as it would appear to the camera—a viewing box equipped with a little optical system for the director.

MOTION PICTURE FILM IN THE MAKING

By George A. Blair

Along with the numerous developments in the past decade and more, in which the motion picture industry has rushed forward so fast and placed itself among the large and leading industries of the country, the Eastman Kodak Company has kept pace in the production of raw motion picture film in the quantities necessary to meet requirements without which the other advances would not have been possible. It is not the purpose of this paper to outline the various steps that have been taken to bring the manufacture of motion picture film to its present state of development, but rather to describe briefly its manufacture and point out the care required to make it uniform in quality.

To manufacture a uniform product in small quantities is one thing, but to make it in large quantities and still obtain a material of unvaried quality is a far more intricate problem. For the latter purpose a wholly different set of apparatus is required, and the development of huge and intricate machines of many different types for large-quantity production has been necessary.

In order to produce film of the highest quality, the greatest care must always be observed and every process carried on in the cleanest surroundings. The importance of cleanliness alone can be understood when it is considered that any fleck of dirt lodged on the surface of the film will be enlarged many times on the screen. After the process of cutting and rolling the film, each strip of stock is carefully inspected to eliminate every piece of film which contains flaws of any kind whatsoever.

In considering the many steps that are required to make motion picture film, it may be well to group the various processes as follows:

(1) The chemical preparation of the raw materials,
(2) Spreading of the support for the emulsion,
(3) Spreading of the sensitive emulsion in a thin layer on the support and
(4) Slitting of large film rolls into stock sizes, inspection and shipment.

We shall now consider these processes in the order named.

Cotton, which is thoroughly cleansed, is utilized in the manufacture of the transparent cellulose base on which the sensitive photographic material is coated. This cotton after being passed through drying machines to remove every vestige of moisture which it contains under ordinary atmospheric conditions, is treated with a mixture of nitric and sulphuric acids to render it soluble.

Special machines, called nitrating centrifugals, are used to mix the cotton with the nitrating acids. These machines consist essentially of large-sized perforated baskets which rotate in vats containing the acid mixture. The cotton is completely immersed in the acid and when the chemical reaction is complete the product, though the same in ap-

pearance, is entirely different in chemical nature, as the original cotton has become pyroxyline or nitro-cellulose.

When the acid treatment reaches the exact stage required, the acid must be expelled instantly and the cotton thrown into water to stop the reaction. The treated cotton is next removed to tanks of water for its first washing, and after being rinsed is passed into centrifugals where water is played on it to remove most of the acid, and then conveyed to other tanks where it is thoroughly washed to remove all traces of acid. The excess water is now removed from the cotton, which is then ready for treatment with the solvents in which it readily dissolves, forming a thick viscous fluid resembling honey, which in factory parlance is called "dope."

The dope is passed through an elaborate system of filters, and finally spread in thin layers on the polished surfaces of enormous wheels, where it quickly hardens and becomes a flexible transparent substance, ready to be formed into a backing for the sensitive coating. It is here especially, that the genius of the factory engineers in solving the problem of large-quantity production has been particularly marked. These wheels form part of immense machines several stories high, weighing approximately 150 tons. The accuracy of these machines is such that the variation from the required thickness of .005 inch is not more than one quarter of a thousandth of an inch.

Silver, which forms part of the sensitive emulsion coated on the transparent base, comes in bars which are placed in porcelain crocks containing dilute nitric acid. Silver nitrate is formed by solution in the acid. The solution of silver nitrate is then poured into evaporating dishes which are placed on steam tables where it is heated to facilitate evaporation to the crystalizing point. After a certain amount of the silver nitrate has been crystalized, the crystals and liquid remaining, which is called "mother liquor," are poured off into draining dishes, which allow the mother liquor to drain. The silver nitrate crystals are re-dissolved and re-crystallized until all impurities are removed. Here again we get that search for purity which exemplifies every operation in the making of high-grade photographic film. The pure white silver nitrate crystals are then placed in porcelain draining baskets where as much of the liquid as possible is drained off. The crystals are next placed in shallow trays and allowed to dry at first on open racks and then in drying closets. They are finally placed in covered jars and stored until needed.

We now come to that mysterious compound, the light-sensitive emulsion on which, when coated on the film base, the invisible or latent image is impressed. By suitable chemical development the image first becomes a negative and is transferred to the positive film and is then ready for projection. From this point all operations in the manufacture of sensitive film are carried on in darkness or dim red light.

To make a sensitive emulsion, a solution of silver nitrate is mixed with potassium bromide dissolved in a solution of gelatine, forming silver bromide which is the compound or emulsion that is sensitive to light.

By carefully controlled methods, only known to the experts and always preserved as trade secrets, this mixture of silver bromide in gela-

tine is converted into the finished light-sensitive product ready for coating on the transparent base. The emulsion for negative and positive film is fundamentally alike, the former, however, being more sensitive and less contrasty than the latter.

The large rolls of sensitized film are then packed in tin cans and stored until ready for inspection and slitting into strips 1⅜ inches wide and from two hundred to four hundred feet in length.

To manufacture a film product of the high average quality now demanded, minute inspection and test at every step in the manufacture from pyroxyline to finished film is essential. This requires chemists in the laboratories, inspectors in the darkrooms and photographic experts who make practical studio and laboratory tests for speed and quality, to which all film is subjected before being finally approved and passed.

Speed determinations are also made by means of the Hurter-Driffield method and are checked by a Chapman Jones plate tester. In the former, strips of film 7 inches long and 2 inches wide are placed in a rotating black sector so perforated as to give with one exposure a series of gradations when exposed for a given time in front of a lamp of known candle power. Each exposure is expressed in candle-meter-seconds. The density or amount of silver for each gradation strip is obtained by means of a photometer and a characteristic Hurter and Driffield, or, as it is commonly known, the H. & D. curve plotted. From the curve thus obtained, the amount of latitude in exposure which is permissible can be readily obtained. The curve commences with a decidedly bent section, and merges into a straight line which finally runs into a curve which is the reverse of the first curved portion. The straight line section indicates the latitude of correct exposure. The H. & D. test is only useful to the manufacturer for the control of the product. The Chapman Jones plate tester with which speed tests are checked consists of a series of strips of varying opacities mounted on a glass plate. Exposures of a certain number of candle-meter-seconds are made through these strips and the resulting densities on the film determined.

Both unperforated and perforated film is produced. The greatest care is taken at all times to perforate film accurately, for unless the perforations are absolutely correct in spacing and alignment, unsteadiness both in the camera and the projecting machine will result. Each machine in the Kodak factory is daily subjected to rigid tests; all guides and punches being carefully examined with gauges which show up to ten-thousandths of an inch variation. A length of film is tested for variation in pitch and is also doubled back on itself to see whether the perforations are uniform or not. Gauge tests are furthermore made for width, and the perforations examined under a magnifying glass to see that their edges are clean-cut and uniform.

The finished film is then wrapped in chemically pure black paper and packed in tin containers which are labeled with the footage length and identification emulsion number, placed in strawboard containers, and is then ready for shipment.

Discussion

Upon Mr. Mayer's request, Mr. Corey showed the Hurter & Driffield curve and explained that the relation of the latitude factor of time to the total exposure time of the plate by over-exposure, varied with every different kind of emulsion, and that he could give no specific value for the average. However, the curve will start down again with very great exposure, giving a positive instead of a negative. In taking an interior with bright windows if it is given too long an exposure, it would be reversed.

Mr. Moulton added that the picture of a bright body against a dark ground will have a halo around it or a dark spot. He supplemented Mr. Corey's remark on latitude by saying that the measurements were taken for direct light and what latitude really means is that within a certain range of practical densities you will get correct relative value for the entire film; whereas, if you over-expose, the high lights will be less dim than they should be; whereas, in under-exposure the low lights will be less dim.

Dr. Kellner mentioned the importance of seasoning a stock by storing it from three to six weeks to take care of shrinkage.

Some discussion then followed between Mr. Richardson, the Chairman and Mr. Mayer on experiences in making film in the warm countries, since film will not stand excessive change of temperature.

Mr. Mayer mentioned the fact that the latitude or exposure curve of the film varies with different portions of the spectrum and did not agree with Mr. Corey on the point that they were working only in the violet portion of the spectrum. Further discussion followed on the effects of climate and length of exposure.

CARBON ARC FOR MOTION PICTURE PROJECTION

By W. C. Kunzmann

The motion picture theater is a permanent institution as is evidenced by the developments during the past two or three years. Hundreds of motion picture theatres have been built which are second to none of the legitimate with respect to size and appointments of interior and exterior. The productions, too, have kept pace with the theaters. These productions now depict on the screen picture plays costing hundreds of thousands of dollars and employ the best of theatrical talent as principals. The picture producing interests have invested fabulous sums in permanent studios fitted with every conceivable contrivance necessary for the production of practically any play and the innumerable feature incidents which occur in the lives of any and all people of this world.

The art of the motion picture is composed of two principal industries, the manufacturing industry and the exhibiting industry. This paper will describe some of the features of the production of light and its projection through the film as applied to the exhibiting of a motion picture.

The resources available today that answer the general requirements of the light source for motion picture work, that is, steadiness, maximum intrinsic brightness and distribution characteristics permitting a high degree of concentration, are the direct and alternating current carbon arc and the high power incandescent projector lamp.

The carbon arc brilliancy of 84,000 c.p. per sq. in. (130 c.p. per sq. mm.) is sufficient for any condition of operation, while the brilliancy of the incandescent projector lamp approximately 20,000 c.p. per sq. in. (or 30 c.p. per sq. mm.) is only sufficient for low-powered installations at present. This paper will deal exclusively with the carbon arc as applied to the motion picture exhibiting industry.

The Projection

The projection system optically is practically in the same state of development as the first successful machine. A line drawing will illustrate the important features of the equipment.

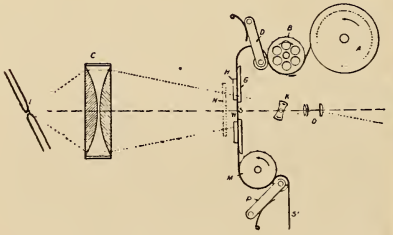


Fig. 1

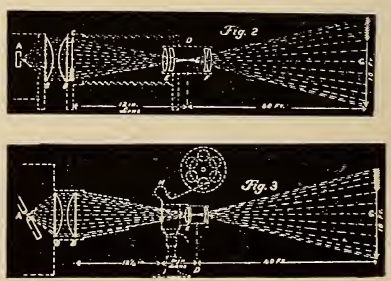


Fig. 2

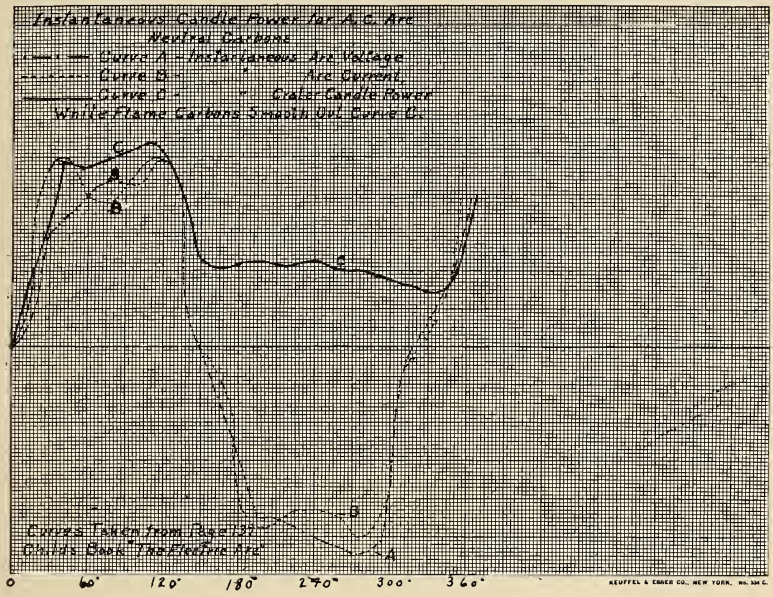


PLATE I.

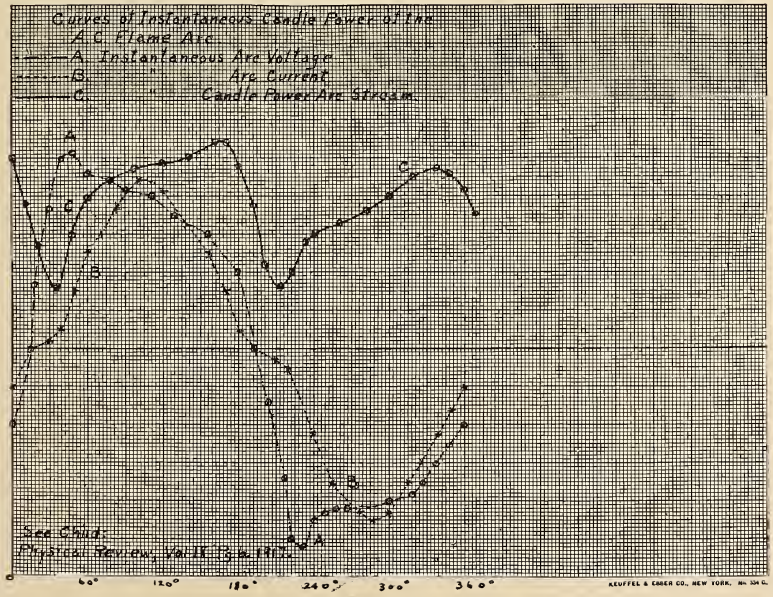


PLATE II.

The light of the arc is gathered by the inner condenser (Fig. 1) into a parallel beam, which is then converged to a spot upon the film. The projector lens is focused upon the film and the light passing the film is then projected upon the screen. The condensing lenses and the projecting lens are independent in size and focal lengths from each other. The former are chosen to best correct the light rays and converge them into the most suitably shaped beam. The projection lens is chosen totally according to the throw and size of screen picture. To get a picture 10 feet wide at 40 feet throw, we merely choose a projection lens having a focal length in inches in proportion to the width of the film picture (roughly 1 inch) as 40:10, that is, 4 inches focal length of lens in this example.

When the projection machine is used as a stereopticon for slides, etc., the projection lens must be of different focal length.

The same principle in calculation is used but now we focus the stereopticon lens on a slide 3 inches wide which is located close to the lamp. Since the same size screen picture is required in both cases (10 feet wide at 40 feet throw) the stereopticon lens must have a focal length in proportion to the width of the slide (3 inches) as 40:10 or 12 inches. (See Fig. 2.)

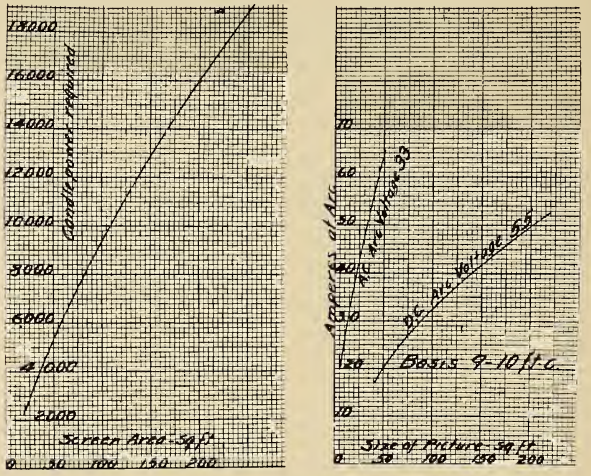


Fig. 3

The Lamp

The entire success of the projection is now up to the lantern and its operation.

The curves in Fig. 3 show the relationship between screen area and the candle power required at the arc, and the current necessary. It is interesting to note that of the total illumination available from the D. C. arc, but 10 percent. gets to the screen, while with A. C. only 5 percent. gets to the screen.

The maximum shown in the curves are no longer maximums but are really minimum values in the better show houses. One hundred am-

peres at the arc for screen areas of 400 sq. ft. are common and even 150 amperes (10 kw.) are being tried. Couple these arc wattages of 7 kw. and 10 kw. with the fact that 60 inch searchlights require only 14 kw. we have some conception of motion picture projection and what it is coming to if present rate of improvement keeps up.

Knowing the amount of current after analyzing theater lighting, screen and equipment requirements, we can select the size of carbons to produce satisfactory screen projection.

Below are given the proper carbon combinations for the different current requirements and also the standard settings for both direct and alternating current projection.

CARBON COMBINATIONS

DIRECT CURRENT

Current	*Size Carbons*
For 25 to 50 Amps. D. C. use	5/8 x 12 inch Cored Upper 5/16 x 6 inch Metal Coated Solid Lower
For 50 to 65 Amps. D. C. use	3/4 x 12 inch Cored Upper 11/32 x 6 inch Metal Coated Solid Lower
For 65 to 70 Amps. D. C. use	7/8 x 12 inch Cored Upper 11/32 x 6 inch Metal Coated Solid Lower
For 70 to 85 Amps. D. C. use	7/8 x 12 inch Cored Upper 3/8 x 6 inch Metal Coated Solid Lower
For 85 to 100 Amps. D. C. use	1 x 12 inch Cored Upper 7/16 x 6 inch Metal Coated Cored Lower

ALTERNATING CURRENT

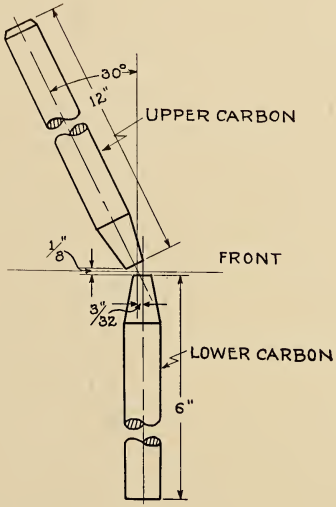
Amperes	*Carbon Diameter*
40 or less than 60	5/8 inch Combination
60 or less than 75	3/4 inch Combination
75 or less than 100	7/8 inch Combination

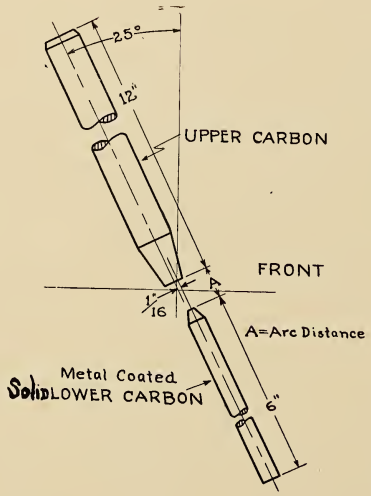
Projector Carbon Manufacturing Process

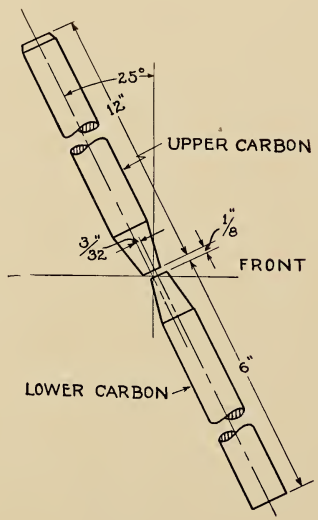
In the manufacture of high-grade projector carbons it is necessary to use an especially prepared carbon flour. The flour is carefully mixed with the necessary binding material and forced by hydraulic presses under high pressure into the desired shape. If a cored carbon is wanted, a steel needle is suspended in the center of the die. The forced carbons are then placed on racks to cool and when sufficiently cool they are cut in the proper lengths for baking. To insure absolute straightness, correct size and perfect stock before baking, the cooled carbons are thoroughly inspected before being turned over to the baking department.

In the furnaces, the carbons are subjected to the temperature necessary to produce a uniform carbon of certain definite prescribed qualities. After the bake is completed, the furnace is sampled and the carbons examined by the testing department before being sent along for finishing. These tests are even more severe than those to which a projector carbon is subjected by the user.

Upon receiving the testing department's O.K., the carbons are sorted for straightness and examined for imperfections, and if they are hollow shells, made ready for coring. Every precaution is taken in the coring department, where the hollow shells are filled to see that the







CARBON SETTINGS

core material fills the entire length of the carbon. The composition of the coring material is of considerable importance as it determines largely the burning quality and color of the arc. After coring, the carbons are dried, finished, pointed, inspected and placed in the shipping stock.

The Carbon Arcs

In the direct current arc, the crater of the positive carbon forms the principal light source. The positive crater is of relatively large area, while the negative spot is small and is not usually considered as a light source. While 95% of the light emitted by the arc comes from the positive crater, the characteristics of the negative carbon are of vital importance in securing steadiness of operation. In operation, the positive crater is set so as to face the axis of the optical system. In setting the carbons in this position, care must be taken to reduce to a minimum the shading of the crater by the negative carbon. In this respect, the direct current arc is superior to the alternating current arc. A direct current arc is longer and therefore gives less shading of the crater. The greatest advantage of the direct current arc is the fact that the current travels only in one direction and therefore the positive crater receives electrical energy continuously and consequently maintains a higher temperature.

As was stated above the characteristics of the lower carbon on direct current are of greatest importance in securing steadiness of operation. The size of the upper carbon is determined by the power imputed to the arc. If the positive is too small the current wil overlap the end of the carbon and the arc will be noisy and unsteady. If too large, the crater covers the end of the carbon and the arc again will be unsteady, because the average temperature at the tip is lower. With the negative carbon, the carrying capacity is the important factor since the size of the negative carbon required by the negative spot is small. A small carbon keeps the arc steady and also eliminates the shadow due to the shading of the crater by the negative carbon itself. This problem has been solved by plating the solid negative over its entire length with a series of metallic coats forming a shell of metal of low electrical resistance around the carbon. This metallic coating volatilizes in the heat of the arc and thus prevents the spattering of the rear condenser lens with the heavy metal beads formed with the old style metal coat. The coating carries the major part of the current and makes possible the use of a small negative with the high currents required by long throws and dense films.

The direct current arc is inherently stable and the range of arc voltage can be made whatever the projectionists desire, but there is one fact to be borne in mind that, for each given current value there is a definite arc voltage at which the arc operates at maximum efficiency. With a constant current value, gradually shortening the arc length, will finally produce an unstable arc; just previous to that point is the limiting voltage for the current chosen. Or, otherwise, a given current requires a certain arc length of voltage. To increase the current and not change the arc length, is equivalent to shortening the arc in the first case and the arc becomes noisy. For this reason increasing voltages are required for increasing currents.

When using small diameter solid metal coated negatives on direct current we start at 52 volts for 30 amperes and increasing by 2 volts for each increase of 10 amperes, reaching 62 for the arc voltage at 100 amperes, a saving of 0.7 kw. or 10 percent. in arc wattage, than in case where the old style large diameter cored negatives are used, starting at 55 arc volts for 30 amperes direct current, and increasing voltage and current in same proportion as recommended in former case.

The arc steadiness and crater formation is materially improved as is shown in the photo (Fig. 4) of equivalent combination in the new and old systems.

In the past when using cored negative carbons the basis for choice of the negative was a ratio of 1 for the negative diameter, to 1.65 for the positive diameter, or a cross-sectional ratio of 1.2.

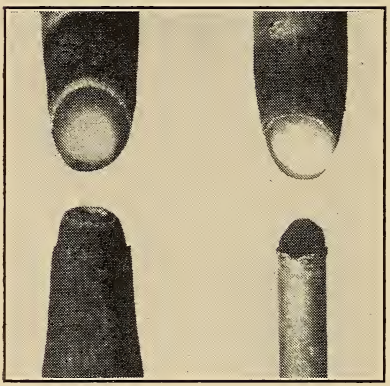


Fig. 4

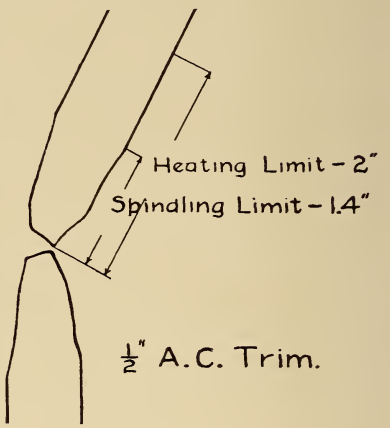


Fig. 5

Under the table of Carbon Combinations for direct current projection, the new developed solid small diameter metal coated negative calls for a cross-sectional ratio of 1.4, the negative having ¼ area of the positive.

What determines the size of a carbon for given service is the ability to stand up under it but the limiting factor differs in A. C. and in D. C.

On direct current the limiting factor is the crater. Since the temperature of a carbon arc is constant just as is the temperature of boiling water—be there a teaspoonful or a barrel full—so, by putting into the carbon more current, we merely increase the number of the hot, light-giving areas until finally the tip of the carbon or crater can no longer accommodate an increase and then no further increase of light is possible for that carbon. The body of the carbon is as yet unaffected by the current but the crater can no longer take care of further increases. This is the limiting factor and so we take the next larger sizes.

On alternating current the crater is but half the size of the crater formation on direct current, owing to the fact that the energy is divided equally between the upper and lower carbon; therefore, we can go still higher in current density on A. C. without reaching a crater limit but we now find that the carbon body cannot carry an unlimited

amount of current without glowing and oxidizing away sharply, so we are limited on A. C. to the physical characteristics of the carbon. Sketch (Fig. 5) shows the physical limitations for a 5/8-inch A. C. carbon. Using the old style alternating current carbon, a short air gap gives a hissing and sputtering arc which is very unstable. By using cored carbons, the cores of which are impregnated with carefully prepared chemicals, an absolutely silent and steady alternating current arc can be obtained. By using the proper chemicals a light source of high intensity is obtained which is far above that of the old cored carbons.

This change in the construction of carbons for use with alternating current projection is one that has come to the front in the last year and has met with marvelous success. It has brought the alternating current arc in close competition with the direct current arc and it has allowed many houses who had seriously considered adopting other sources of illumination to continue with the alternating current arc without necessitating a single change in or about the lamp house or in the wiring. The mere substitution of these new carbons for the old style alternating current carbons makes the alternating current arc a very desirable and economical light source for projection.

In addition to fulfilling the general requirements, the carbon arc has other characteristics which make it adaptable for motion picture work. These characteristics are: 1—Color of light; 2—Reliability; 3—Flexibility; 4—Steadiness.

Color of Light: Until recently, the color of the light used for the projection of the high-class film was a source of much annoyance. It is obvious that where the picture is taken in the open and in bright daylight, the effect upon the screen would be inferior unless the projection light source approached that of daylight in color value. The light of the direct current arc is the nearest approach in color value to daylight of any of the known illuminants that could be used for motion picture projection. The light is a pure white of high intensity. The light of the alternating current arc using the modern high-grade projector carbon approaches that of the direct current arc both in color value and intensity. A pure white light is beyond doubt the proper kind of light to use for projection since it brings out the high lights and shadows and will project upon the screen a picture that will please the most critical audience.

Reliability: The arc in the hands of an efficient projectionist, is a very reliable light source. It is not easily affected by fluctuations in line voltage and therefore will give an even screen illumination where other illuminants will fail. Carbons have a definite length of life and therefore the projectionist can guard against the failure of light in the middle of a reel of film.

Flexibility: The carbon arc gives a steady, flexible light, variable at the will of the operator according to the density of the film. No two films are alike and no two parts of the same film are of the same density and consequently to give a true artistic presentation of any picture you must have a flexible light source.

Steadiness: Both the direct and alternating current arcs are giving absolutely steady illumination. The traveling of the arc and negative

shadows have been eliminated in arc projection.

In conclusion, emphasis should be placed upon the use of proper carbon combinations. The carbon manufacturer specifies a definite diameter of carbon for a definite current requirement and any deviation from this will result in poor projection. If the projectionist is without positive knowledge of the amount of power he is using he can obtain this by means of a voltmeter and ammeter. Standard instruments for this purpose can generally be obtained from the local power plants.

Discussion

In reply to some questions as to the relative efficiency of direct current and alternating current arcs, Mr. Ward said that it took about twice as much power with an A. C. arc to produce the same screen illumination as with D. C. With a small metal coated negative, the arc is steadier and is from 10 to 15 percent more efficient.

Mr. Mott contributed some remarks concerning the new white flame, A. C. carbon. The white flame material in A. C. carbon gives 10 to 15 percent. more candlepower, and since the light is whiter, the acuity is greater. The Navy Department made tests showing that the spectrum of the white flame carbon arc more nearly resembles daylight than neutral arcs.

The crater is hotter and there is more light in the arc stream, owing to the vapor from the white flame material which fills in the time and form deficiencies of the wave form. For this reason the stroboscopic effect is lessened; this white flame arc has the further advantage of being comparatively noiseless.

Mr. Kunzmann said that accurate data is available regarding the proper sized carbons to use under different conditions, and, as this is the secret of good projection, there is no reason why any projectionist should use the wrong trim.

THE PROJECTION ROOM AND ITS REQUIREMENTS

By F. H. Richardson

This article is presumed to deal with the projection machine enclosure, and to set forth, as briefly as may be, some of its more important requirements. It would, therefore, seem fitting that a short resume of the evolution of this enclosure, from a cloth walled affair to what it now is, will not be inappropriate.

In the earliest days of the industry, the projection machine enclosure was usually merely a surrounding drape of black, or dark colored cloth, designed merely to conceal, or partly conceal the apparatus and its attendants from the audience. This form of enclosure continued to be used until motion picture theatres came into existence. The advent of the theatre very naturally suggested a more permanent housing for the projection apparatus, and the need was first met by a wooden-walled room, which, probably by reason of its smallness and the nature of its immediate predecessor, was dubbed the "booth."

Films coming from the projector were run either into an open basket, or a sack attached at its open end to a hoop. This plan was later changed by substituting a large metal tank, which same was made to act as a base for the projection machine itself. Operators (they were little more than mere operators of a machine in those days) were allowed to and usually did smoke at will. The top of the metal tank was often used as a convenient shelf for temporary deposit of red-hot carbon butts, whence one would occasionally roll into the opening of the film tank. As may well be imagined, the combination of a wood-walled room, cigar and cigarette butts and red-hot carbon stubs made for trouble. The resulting fires raised a tempest of very caustic newspaper comment, and the demand for a fireproof enclosure for the projection apparatus. Incidentally it was the tremendous speed of combustion occurring under such circumstances (one and often two reels of film run into a sack or tank in a loose pile) which gave rise to the absurd, but for several years very familiar, "Film Explosion" newspaper scareheads.

The first result of the fires (several of which were rather serious in the item of property loss, and a few in injury to theatre patrons, the latter resulting almost entirely from panic) was an attempt to fireproof the enclosure by covering its walls with sheets of either tin or iron. This proved highly ineffective, and was later ordered put on with locked joints; still later the metal covering was backed with sheet asbestos.

Some very amusing instances of official stupidity occurred in connection with the early attempts at fireproofing. Chicago had just passed an ordinance requiring the interior of all picture shows located in buildings in which families lived, to be fireproofed with pressed steel, backed by sheet asbestos 3-8 of an inch thick. An inspector visited a North Clark Street "store room" theatre, on one side of the auditorium of which was a 24-inch brick wall, finished with plaster ap-

plied directly to the brick. He actually threatened to close the show unless that wall be immediately fireproofed as per ordinance.

Gradually these makeshifts were improved upon, however, until we have today many examples of really very fine projection machine enclosures, though there is still a sad lack of any generally applied adequate standard as to either size, construction, or other items, and it is for the purpose of supplying a basis for these standards this article has been undertaken.

In the beginning of the industry there was slight need for any other than very rudimentary knowledge or skill in projection. Motion pictures were a novelty, and people paid to see them as such. Projection machines were small and their workmanship crude. The illuminant was weak. The photography was poor. The perforations were anything else than accurate. The screen was merely a square of muslin, and as long as there was something resembling a motion picture somewhere on the front wall of the auditorium, everyone was well pleased. Technical knowledge, as applied to projection, simply did not exist. No one gave the "booth," or what it contained, a second thought, except to abuse the "operator" when he stopped the show too frequently to mend broken film, run too long out of frame, or requisitioned too many repair parts. The projector enclosure was placed in any space within sight of the screen which could not possibly be utilized for anything else. It had neither ventilation, nor toilet facilities. It was made the subject of a flood of absurd rules and laws, formulated by men who knew absolutely nothing about the real requirements. It was, literally, the very last thing to receive consideration as the industry advanced, and years of vigorous fighting were required to bring theatre men to a realization of the fact that the room from whence the picture is projected lies close to the very heart of things.

The business of the projection of motion pictures had to be literally dragged up out of a mire of almost contempt, and established on a plane of respectability. That recognition to which its importance justly entitled it had to be fought for, and has been partly won, but the battle is not yet over. I venture the assertion that the future will see the projection of motion pictures accorded recognition as of equal importance in artistic possibilities with any other branch of the industry, to say nothing of enormous possibilities for economy through accurate knowledge and intelligent handling of the mechanical, electrical and optical details of projection installations.

To dispute the proposition that the room we are about to discuss is the very heart of the motion picture theatre is equivalent to contending that one plus one does not make two. When the producer, his directors, high-grade camera men, high-salaried artists, dozens and maybe hundreds of lesser lights and his dark-room men and assemblers have all done, the finished product, be it the "Battle Cry of Peace" or the humble efforts of the screen "Barn-Stormer," must perforce be turned over to the man in charge of projection for reproduction upon the theatre screen before the final judge, the public. And who will dare say that poor equipment, poor working facilities or lack of skill will not either almost entirely ruin, or at least largely detract from the artistic value of the finest production ever made, thus largely impair-

ing its effectiveness with the audience? And if this is true, does it not follow that the projection machine enclosure, including its contents and the men in charge, are of huge importance to the industry?

For the foregoing prelude I make no apology. If there is objection to space consumed, just consider the amount of space used up during past years on subjects of far less importance to the industry, and hold your peace.

To begin with, the writer very seriously objects to the name given the projection machine enclosure, namely, "booth." Webster, who is presumed to know what is correct in words and language, tells us a booth is a "temporary structure of boughs; a shack."

For many years I have used the name "operating room." This, however, while a very decided improvement over "booth," does not quite fill the bill. It seems to me that, logically, the room from which pictures are projected is a "projection room," and the writer respectfully suggests to this body its adoption by the department of nomenclature. It will be hereafter used in this article.

The only possible objection to the use of this name is the fact that some theatres and producers have applied it to the room where pictures are screened for examination. Such rooms are, however, properly either "exhibition" or "screening" rooms, and that a misnomer has been applied should not, I think, prevent applying the logically proper name to the room from which pictures are projected.

Structure: The projection room must have fireproof walls, floor and ceiling. The floor must be solid and free from vibration, as any vibration communicated to the projectors will inevitably affect the screen result. For the floor I would, therefore, suggest not less than four, and preferably six inches of the usual mixture for "rich" concrete, the stone to be not larger than will pass through a one-inch screen. Over this should be a one-inch top dressing, guaranteed not to disintegrate into dust. Many cement finish floors show this fault, and it is a very serious one, since the dust gets on the films and into the delicate machine parts, where, due to its nature, it acts as an abrasive and does great, though slow, damage. For this reason I would suggest that the top dressing might better be tile, similar to that commonly used for bath room floors. If cement is used, it should be treated to an acid bath to harden its surface. Such a bath is available, but its application would very nearly make the cost of the cement finish equal to that of tile, and tile is much to be preferred, from any and every viewpoint.

Note.—Since the foregoing was written I am informed there is a varnish which is giving satisfaction in generator and other rooms in which this fault has been experienced. This matter will be looked up and the name of the varnish announced through the usual channels later.

In wall and ceiling construction, there are the following points to be considered, viz: fireproofing, soundproofing, rigidity and lack of heat-absorbing and retaining qualities.

For permanent installations there is nothing that so well fills all these requirements as six-inch hollow tile, set in, and plastered on both sides with rich cement mortar. Such a construction is, by com-

parison with brick or concrete, light in weight (an important consideration in some circumstances), quite thoroughly soundproof by reason of its interior air space, sufficiently rigid for all practical purposes; also it neither absorbs nor retains the heat to any appreciable degree. Hollow tile is, therefore, the best possible medium for projection room wall and ceiling construction. Four-inch hollow tile may be used for the ceiling, but six-inch is best for the walls.

Next in order of excellence is concrete. The objections to this material, as compared to hollow tile are threefold, viz.: excessive weight, absorbs and retains heat, and, unless of considerable thickness, acts to some extent as a sounding board to distribute sound inside the room out into the auditorium.

Following concrete comes brick. Its objections are weight, cost, heat-absorbing qualities and difficulty of ceiling construction, where same is necessary.

For permanent installations what is known as the asbestos room should not be considered at all, except its present construction be radically changed. As at present made its ceiling is not high enough; also, its walls and ceiling act as veritable sounding boards for the distribution of sound, though it forms an acceptable fireproof room for strictly temporary installation. With double walls and ceiling, with an air space between, and an eight or ten-foot ceiling height, it would serve very well for permanent use.

Dimensions: It is not to be reasonably expected that the projectionist will do his best work if placed in crowded, cramped quarters. Space inside a theatre is valuable, especially if it can be utilized for seating, hence exhibitors begrudge every inch surrendered, and usually try to reduce the projection room to its least possible dimensions, which is extremely poor policy, when carried to the point where projection is made to suffer. So far as the writer knows, up to date every legal standard set up for size calls for a too small depth, front to rear.

The shortest of modern professional projectors measure four feet three inches front to back when setting level; considerably more when at an angle. The setting of projection machines up against the front wall is poor practice. There should be at least 18 inches between lens and wall when machine sets level, and not less than three feet in the clear behind the projectors. Taking everything into consideration, nine feet may fairly be set up as a standard front to rear depth for projection rooms, with the notation that ten feet is better.

The width of the room should be a minimum of six feet for one machine, with three feet of added width for each additional projector, spot lamp or stereopticon. The minimum distance from the floor to the ceiling should be eight feet, with the recommendation that added ceiling height be provided where possible. A high ceiling is very desirable, both from the viewpoint of health and comfort and in case of fire, since it provides a reservoir for the heated air above the heads of the men, and for gases and fumes, should a fire occur.

Ventilation: This is indeed a most important item. Let it be first understood that pulling the fetid atmosphere in from the top of a hot auditorium through the projection room ports does NOT constitute ventilation. The projectionist is human, and it is nothing less than a

crime to compel him to breathe such air. First, there must be vent flue in the ceiling, or in the wall at ceiling height, leading directly to the open air, and this vent should be of metal, with locked joints. It should have an inside diameter of eighteen inches and should be thoroughly insulated from all wood work, since it is apt to become very hot in case of fire. In this pipe, should be installed an electric fan not less than 18 inches in diameter, so wired that while its speed may be controlled by the projectionist, it cannot be stopped while the projector is running; also the wiring should be so arranged that the dropping of the fire shutters will automatically start the fan going full speed, in case it is running slowly. This latter is of the utmost importance as an adjunct to fireproofing, since in case of fire, unless the smoke and fumes be pumped out, they will or may filter out into the auditorium, where-

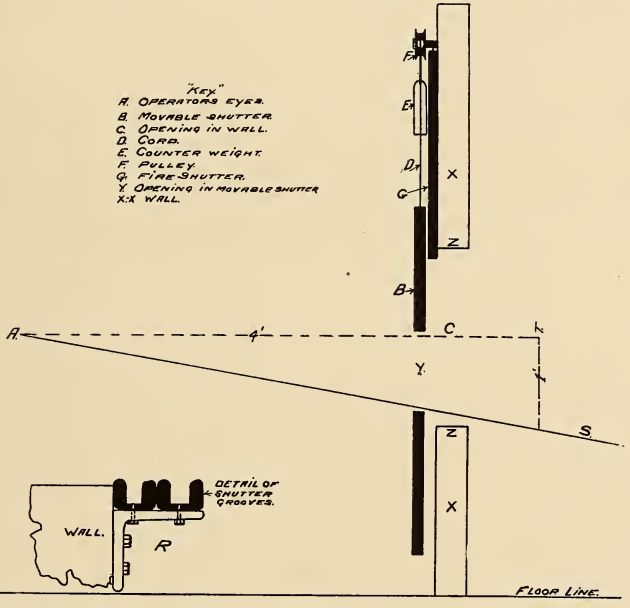


FIG. A

Sectional detail of adjustable observation port shutter, with special detail showing construction of channel iron grooves for same.

upon the inevitable cheerful idiot will yell, "Fire!" and you all know what happens then. Second, there must be one or more fresh air inlets at or near the floor line, leading directly from the outer air. In this connection, I would recommend the Massachusetts law, which requires a fresh air inlet not less than 15 inches long by 3 inches high on each of the four sides of the projection room, same to be located not more than 2½ inches above floor line. There should also be an inlet in the center of floor, if possible, otherwise in center of rear wall, not more than 2½ inches from floor, same to have an area of 160, 200 and 280 square inches, respectively, for one-machine (six feet wide), two-

machine (nine feet wide) or three-machine (12 feet wide) room. The same law requires a twelve, sixteen, or eighteen-inch vent pipe, respectively, and fan for different size rooms, but with this I am unable to agree, since a burning film will make just as much smoke and fumes in a small room as in a large one. Eighteen inches should, in my opinion, be the absolute minimum diameter for projection room vent flues. Third, all lens and observation ports should be covered with glass in order to prevent the pulling in of foul air from the auditorium as well as to prevent smoke entering the auditorium in case of fire. The inlet fresh air ports should be provided with shutters, arranged to automatically close in case of fire, when the port shutters are dropped. The dropping of these shutters will compel the exhaust fan to suck air in around the cracks of the port shutters and door, thus preventing any smoke from seeping out.

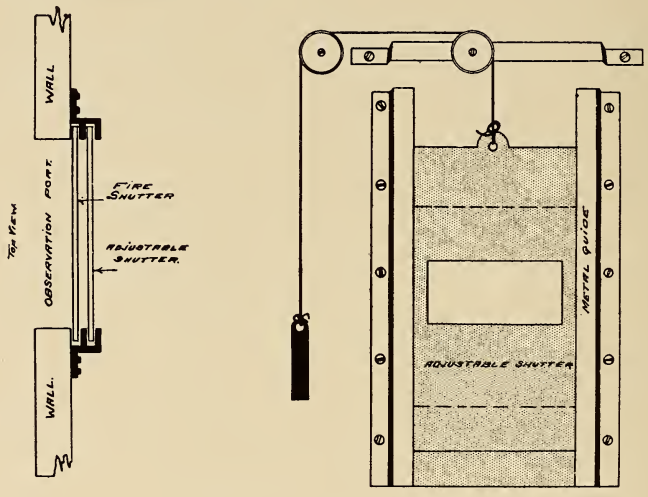


FIG. B

Showing elevation of adjustable shutter, and detail of its relation to the regular port fire shutter.

Sanitation: It is absolutely essential that the projection room be applied with toilet facilities. This is so obvious that argument should be and is, I think, unnecessary. There should also be a wash bowl, with running water. The projectionist's hands become soiled with oil and carbon dust, and it is better to wash this off with water than to wipe it off on films worth $125.00 per reel—yes, quite considerably better.

Observation and Other Ports: This is an extremely important item, and one subject to great abuse. It is utterly absurd to expect a projectionist to put on a high-class reproduction of a photoplay if he must squint at it through a sort of glorified knot hole. *It is absolutely essential to high-class projection that the observation port be of size sufficient to allow the projectionist a full view of his entire screen from ordinary projection position.* The position of the observation port as to height from the floor will depend, of course, upon projection pitch. I have always

recommended, and do still recommend an opening in the projection room wall 12 inches wide by 24 inches high, same to be covered with a sliding shutter, hung on a counter weight moving up and down at the will of the projectionist. In this false shutter there should be an opening ten inches wide by six high. By this plan, we have a port six inches high by ten inches wide, adjustable as to height over a range of 24 inches. Such a port shutter is illustrated, Figs. A and B. Its construction (too lengthy to be incorporated herein) is described in detail, pages 218 to 220, inclusive, Richardson's Motion Picture Hand Book for Managers and Operators. All lens and observation ports should be covered with glass, as already set forth. Lens ports should be no larger than is necessary to pass the actual effective projection ray.

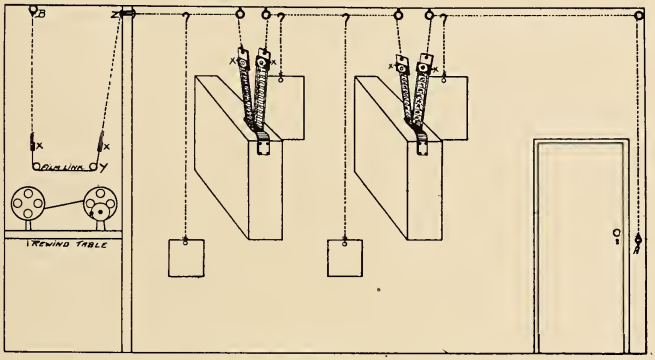


Fig. C

Showing method of suspending individual shutters from one master cord. This may be and is done by means of patent devices which serve the same purpose, but are in reality little or no better; in fact they may be not so good, since by their use the fuse link is almost invariably located a considerable distance from any possible seat of fire. As in this illustration it is the *idea* which is illustrated, its practical application varying with the individual installation.

Position of Projection Room: This is a subject so well understood that its discussion would be largely a waste of space, except to say that it should never be less than 50 feet from lens to screen, if a picture twelve feet or more in width is to be projected. Its permissible height above the screen has already been taken care of acceptably by this body.

Port Shutter Fuse Links: It is, of course, necessary that all ports be covered with shutters of fireproof material, so arranged that they will fall automatically in case of fire, *and do so within a very few seconds of the starting of the fire;* also, so arranged that they may be instantly dropped by the projectionist. The usual present practice in location of fuse links renders them of no practical value. I have for years recommended the substitution of links of film for metal fuse links, and have insisted that they be placed as closely as possible to every probable seat of fire. As I have repeatedly pointed out, it is imperative that the fire shutters drop within 5 seconds of the start of a fire, else they might almost as well be left up altogether. It is not the fire which works in-

jury to an audience. With a modern fireproof projection room it is practically impossible for fire itself to work injury to any individual of an audience. It is the resultant panic when some one invariably present where an audience assembles, sees smoke or fire and spreads the alarm at the top of his voice, usually accompanying it by a rush to the door. In view of this fact, it would seem advisable either to do away with fuse-links altogether, educating the projectionist that the first act when fire occurs is to drop the shutters, or else adopt a better-placed, quicker acting fuse. Some idea of such fuse-links are shown in Figs. C and D.

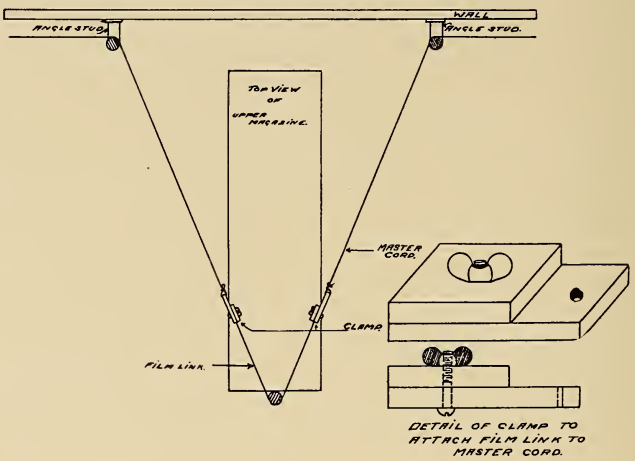


FIG. D

Showing detail of film link to be placed immediately over projector aperture, where fire will strike it very quickly. A still better plan is to cut a narrow slot in front of upper magazine, at front, near top, passing a link of this film-fuse through same into magazine with a bit of wire thrust through to hold same, so that when fire strikes it fuse will be released instantly. There are so many ways of accomplishing the end that in this paper space will only admit of the *idea* being conveyed. The best method of application, remembering the main idea is to secure instant severing of the link when fire starts, must be left to the individual to work out.

Equipment: I think it is unnecessary to deal with the equipment of the projection room in this paper, since it could by no stretch of imagination be made the subject of standardization, as an equipment; though its parts should have attention.

Projectionist: There is, however, one subject further which, it seems to me, deserves notice; viz.: the title of the man in charge of the projection room. The term "operator" is nondescript, non-descriptive and not at all in keeping with the business of projection of photoplays. We have telephone operators, telegraph operators, etc., etc., almost without number. Presumably we call the man who projects pictures an "operator" because he operates a motion picture machine. By precisely the same logic, the locomotive engineer is an "operator" because he operates a locomotive, and the organist is an "operator" because he operates an organ.

If a man merely attends to the mechanical operation of a machine which does the same work in the same way constantly without opportunity for initiative on the part of the person in charge which will alter and change the finished result, then I grant you the man in charge is merely an operator of the machine. But who will say the locomotive engineer, the organist, or the man in charge of projection does no more than this! As a matter of fact, the latter must have initiative along several lines, as well as a wide knowledge of electrics, optics and mechanics. The man who projects pictures is logically, it seems to me, a "projectionist." That title is descriptive, appropriate, and, at least in some measure, dignified. I would, therefore, suggest to the Department of Nomenclature the word "Projectionist" to designate the man who projects pictures, in lieu of the present inappropriate term "operator."

NOTE.—Since this paper was prepared and read the Society has, by unanimous vote, adopted the term "projectionist" as designating the man who projects motion pictures professionally.

DISCUSSION

After Mr. Richardson's paper some general discussion followed on the preference of the term "projectionist" for operator. The question of some arrangement to enable the projectionist to see the scene and know whether the picture is in focus or not was taken up. Since it is impossible to view a picture while standing in a bright room, two methods of overcoming this difficulty were suggested. In some theatres, the cone of light is hooded leaving the room dark; in other theatres, a glass port hole is used with a hood painted black inside.

Sanitary conditions in the operating room were touched upon and the statement made that six hundred (600) operators die annually from pneumonia. Mr. Kunzmann said that while much of this was attributed to carbon fumes, that experiments had been made proving that there was nothing in the carbon fumes or the air in the projection room to injure the projectionist, if the room was properly ventilated.

It was recommended that every port hole including that through which the beam of light passes to the screen be covered with glass to prevent the impure air from the top of the auditorium coming into the booth. Dr. Kellner places the loss in light, if the port hole through which the beam of light passes is covered with glass, to be from 8 to 10 percent.

NATURAL COLOR CINEMATOGRAPHY

By William V. D. Kelley

On several occasions upon being attracted to a theatre where color motion pictures were advertised we were disappointed upon finding them to be black and white hand-colored films. There is, therefore, a rather small difference, in words, between the films that I have started out to discuss and the other films with a similar name.

Color motion pictures may be said to be the usual type of black and white value films arbitrarily colored with dyes by means of stencils or hand work and painted to suit the individual taste.

Natural color motion pictures for the moment and until a more distinctive description is given to the title, may be understood as being those photographed so that the colors are selected entirely by optical and mechanical means and reproduced again in a like manner. It is this type of film that I am to discuss with you.

The subject is a massive one and as I have not the time this year to go into details as to the *modus operandi* of each of the steps involved, this paper is simply an attempt to introduce the subject broadly with the hope that the several other color workers in our Society, and the many members, not immediately concerned but who have shown that they are intensely interested in the subject, may continue the work at subsequent proceedings of the Society.

Standards

A successful commercial film in natural colors should meet our Society's standard in one respect:

Film Speed.—A film movement of 60 feet per minute through motion picture mechanisms shall be considered as standard speed. (Standards adopted S. M. P. E.)

Other standards already listed and which help to make for advancement in this color field:

(*a*) Frame Line. (Standards adopted S. M. P. E.)

(b) Perforations. (Standards adopted S. M. P. E.)

Projection

Probably all projectors in use today throughout the world are designed to operate at a film speed of 60 feet a minute with but small latitude for satisfactory operation at higher speeds. In order to enjoy to the fullest a commercial success and to give to the greatest number the enjoyment that color lends to so many subjects, we must first meet this requirement and produce a film capable of giving its best on these machines.

Such films may be combined with the black and white subjects; joined, cut, assembled and in general behave so that the projectionist customarily handling film can use them without special instruction or training.

Commercial positive films are those in which each image area is substantially complete as to color rendering. The colors are in the film in the form of dyes, metals or other color compounds. The black and

white records may or may not exist, depending on whether the films are constructed on the additive or subtractive methods.

Each alternate image area may vary in its colors so that the fullest color rendering is only obtained on projecting. For example, each alternate color-image may be a representation of the Reds and Greens, while the second set of alternating images may be a record of the Orange-Yellows and Blue-Violets. The colors fuse or combine when projected.

We are nearer to a successful realization of this form of color film than many of you are aware, and it may be of interest to point out a few of the suggested or attained methods.

(*a*) *Single Coated Emulsion.* Two or three-color images are impressed in the gelatine. Usually one of the color-images is the result of the silver in the original emulsion, with the second color-image obtained by means of a sensitive bichromate salt. If a third color-image is to be impressed into the emulsion in register with the first two, it may be applied by imbibition.

It is quite possible to get the two colors in the single emulsion. I have done so, in projectionable lengths. There are certain obvious drawbacks, however, from a commercial aspect.

(*b*) *Two Emulsions on One Side.* The first color-image may be a blue tone in the original coating. A second emulsion is then coated over the first one, printed, and the silver converted to a red color by toning or otherwise. I have seen reels of film produced by this method that appeared to be satisfactory, but I understand that there are manufacturing difficulties. It always seemed as though it was too long a wait, after finishing the first color-image, sending the film back to a red lighted coating room for a new coating, a new printing and development and a second coloring before determining if everything had gone right on the first tone. Not to speak of the added difficulties of registration due to alteration in length, the expense of making short lengths and so on. (The Fox system follows this procedure.)

(*c*) *Double Coated Emulsion.* Here we have a celluloid base with a silver emulsion on each side. Both sides are printed before development. If on a two-color basis, all of the red value pictures are printed on one side and all of the green value pictures on the opposite side in register, and after development the black images are converted or transposed into color-images. This process is "healthy" and will, doubtless, be the first to reach the market in some form or other.

(*d*) *Single Coated Emulsion.* The celluloid base is colored in fine dots or lines. In one method published, the celluloid is passed over suitably engraved rollers and fine ridges impressed in the base forming hollow spaces, similar to the raised portions on the opposite side. These depressions are filled with colored inks, red on one side and green-blue on the other. Variations provide for 3 and 4 colors. The emulsion must be color sensitive and the negative printed with colored lights or their equivalent. (See Dufay U. S. Patent No. 1,155,900.)

Some other developments are not far enough advanced for me to give you a description now Those described will serve to show you the general direction of the work. Many of these and similar ideas were discussed or described seven or eight years ago, but the difficulties of

producing on a commercial scale crop out in unexpected places, thus delaying the progress of the industry.

Coloring

Two methods of coloring films are as follows:

First: Those in which the color separation images are in black and white, representing the Red and Green values alternating throughout the length of film. The entire image area of the Red value pictures are dyed that color over the black records and the same for the Green records. The pictures may be projected at high speed to overcome the pulsation of the colors, or on a special machine which exposes two images at one time and superimposes them on the curtain. This system is not adapted to present standard methods of projection.

Second: The conversion of the silver images to color is one means available if the pictures are to be produced on the subtractive basis. This method gives us clear gelatine in the whites, the black being made up of a full density of the colors used. The print from the red negative is colored its complementary color green-blue and the print from the green-blue is colored red.

Broadly—the silver is converted to a salt or a compound capable of holding dye.

(*1*) Traube, U. S. Patent No. 1,093,503 of 1914. Silver converted to silver iodide, dyed, and the more or less opaque iodide removed. Uses basis dyes.

(*2*) Miller, U.S. Patent No. 1,214, 940 of 1917, produces a transparent mordant by treating the silver image in iodine, and potassium iodide. This fixes basis dyes.

(*3*) Wm. F. Fox, U. S. Patent No. 1,256,675 of 1918, provides for toning by Ferric Salts for the Blue and with Uranium for the Red.

(*4*) W. I. Crabtree, The Photographic Journal, August, 1918. Toning with Copper to provide a mordant for basic dyes.

The following is just the reverse of the above. The dye goes into the clear untanned gelatine.

(*5*) J. G. Capstaff, English Patent No. 13,429 of 1915. The silver image is bleached and tanned so that the dye goes into the gelatine in proportion to the amount of silver that was present. A negative gives a negative. So it is necessary to use a positive print in order to obtain a dye positive. This process is known commercially as Kodakchrome.

Negatives

As in black and white photography, you must "get it in the negative" before it is possible to get it on the screen in anything like natural colors.

The camera controls these vital questions:

(*e*) Exposure

(*f*) Fringing (Result of rapid action where single records are made successively.)

(*g*) Parallax (Result of taking through multiple objectives so that portions of the view do not register.)

The suggested or tried methods for overcoming parallax and fring-

ing are numerous. The photographing of all of the color records at one time is the obvious means. A single objective must be used if the views are to be free of parallax. The use of two or three objectives with multiple exposures is feasible in overcoming fringing, but introduces parallax.

Campbell (English Patent No. 2,786 of 1913) suggests a way of using multiple lenses and overcoming parallax by blurring the portions that are "out of register" and the scheme appears workable, the main drawback being the fact that the short focus lenses usually employed for cinematograph work cannot be used.

However, the camera employed to date by one company takes negatives in which the pairs of records are in sequence on a single strip film taken singly without parallax and it is a fact that 95% of the negatives are without noticeable color fringe. Color fringe is due to the fact that successive stages of the action do not register as regards color, a moving white object particularly being preceded and followed by stripes of pure color when projected.

It seems to me that a camera taking single records at each exposure satisfies the commercial aspect, especially as the negative is workable in connection with the commercial positive film.

The negatives are photographed through gelatine color filters and in the two-color system consist of blue-green and red-orange so that one record is made through blue-green followed by a record taken through the red-orange. It requires both of these records in each frame of positive to make up our complete color record of the commercial (16 pictures per second) film. Consequently twice the footage of negative is required in recording the scene as compared with black and white negative of the same scene and this holds good with all systems or schemes with the exception of the "d" (Dufay) film mentioned above.

Exposing 32 pictures a second through color filters is some job too. However, an increased exposure period in the camera plus a very important improvement in the filters makes the work quite practicable.

Filters

These are colored gelatines, usually mounted between two optically flat glasses. They have the property of passing certain colors and absorbing certain other colors. A complementary pair of taking filters will, for example, allow the orange and red to pass through one of the pair and record those values on the film in the final form of developed (reduced) silver, while the green and blue light reflected from the objects being photographed will pass through the green-blue filter. This explanation, however, is only partially true, as the conditions only hold good at certain intensities of light. Either of the filters in the pair will record white light and will pass red-green and blue light if of sufficient intensity. It is this necessity of recording the whites and greys and still preserving the separation or isolation of colors that is responsible for the Raleigh-Kelley Patent U. S. A., No. 1,217,425 of 1917.

By this means, to each exposure through the color filter is added on the same image area a neutral exposure which has very much the same effect as the addition of the grey print in quadricolor printing, and while this about doubles the exposure, it is also found to wonderfully

enrich the picture with pastel shades such as are found in nature. It helps to furnish detail and round out the picture.

Printing

All color record negatives are in sets of from two upwards. Therefore, the simplest form must use two records, separated in some manner. Aside from the "d" method described under "Positives" some suitable means must be found for bringing the records into register.

Most of the appliances are optical and those interested can look up the Brewster U. S. Patents and the Capstaff English patents for descriptions of their methods. Fox of Kinemacolor uses a still different optical form, which is virtually two printers, facing each other. One feeds the negatives two image areas while the other feeds the positives one image area, so that the records of one color follow each other in close sequence on the positive. The negative is illuminated and projected by a lens system to the positive. The same operation is followed for the second color. Prizma prints by contact, depending on the sprocket holes. Absolute registration must be had on the positives, for if this is not secured the pictures will not appear sharp and clear, even though the lack of registration is not otherwise objectionable.

Productions

Probably very little work has been done abroad during the past few years with color cinematography. In the United States several groups are busy with the problem and some have reached the market or have been given public showings.

Kinemacolor gave up its wheel screen showings and devoted itself to perfecting the Fox process, which is covered by description under "B" heading above.

Technicolor two-color taking process. Camera records two color value records of each exposure, simultaneously, but not adjacent through one lens. Rapid movement resulting in fringing is therefore eliminated. Public showings were on a special type of projector which superimposes two images on the curtain at one time. This process appears to be technically correct, but is not adapted to standard projection in its present form.

Cinechrome two-color taking, two adjacent images being recorded at each exposure. Projection by means of a special projector superimposing two images on the curtain at one time, eliminating fringing and pulsation. Very much the same as the Technicolor process.

Douglass two-color taking records being made singly in succession and projected in that way at high speed. Does not use color wheel, but dyes the red positive record red and the green-blue positive record green. Public showings in New York did not indicate any improvements over similar methods showing before its advent.

Kesda. Working on a method for producing a film that projects at sixteen pictures a second—standard.

Prizma. Double complementary pairs of images used in taking. One pair records the red-orange and blue-green values, the second pair records the orange and blue values. (See description under "Filters" for an added feature used in making the negatives.) Their new positions project at 16 pictures a second—standard.

In addition to the above the Eastman Company possesses the Chronochrome process of Gaumont using three colors in taking and projecting. Members of the Eastman staff have also developed a commercial process, in which double coated positive stock is used and the dyeing applied by the (5) Capstaff process described above.

Patents

In England the patents for steps useful in color cinematography are several hundred, while France and Germany have done their share. In the U. S. we have the grand-daddy of them all—Mr. F. E. Ives, issuing frequent patents on this subject. Several others are mentioned in this paper, but it is too big a subject to cover now

Some inventors anticipating the direction that this work would ultimately take have endeavored to cover up by patents the principles that would apply. They have been more or less successful in this, but as it is a lifetime work for any individual to have covered all the steps, some patents wait for the art to grow up to them.

Future

I quote from "Photoplay," for September, 1918.

"Imagination's one expression is art, in some form or other. What music has meant to Italy, painting to France, the novel to Russia, and dramatic literature to England, the moving pictures will mean to America.

"Yesterday America was the only believer in the moving picture; today it is the only developer; tomorrow it will be the only master of the craft."

Up to the present we have lacked the paint brush and palette. No motion pictures in natural colors approaching the possibilities of this art have been shown. No artist has had his opportunity. Motion pictures, grander and more perfect than those paintings adorning the museums of the world are in store for the world, in motion. I have seen the "signs" and know that they are near.

Discussion

Mr. Burrows asked just how the colored image on the film was obtained.

Mr. Mayer, by way of illustration, showed samples of the double emulsion process film—emulsion on both sides of a celluloid base. In the negative, one frame is taken through a green filter suppressing the reds; the corresponding frame is taken through a red filter suppressing the green. From this negative, the print is made with one color value on one side and the other color value on the other side, and is then dyed in order to render the field of transparency on one side, a match-up with the color on the other side. In other words, the negative separates the color values and the color is restored by superimposing the prints of the various color values. Then followed a brief description of different methods of taking these negatives and the advantages and disadvantages of each.

THE FUNCTION OF THE CONDENSER IN THE PROJECTION APPARATUS

By Hermann Kellner

Light radiates from every point of a source in all directions. If we had a very intense, and at the same time cold, point-shaped source, projection would be possible without any additional optical apparatus. Supposing we have such a source *s* separated by the distance *d* from a stencil *t* and at a distance *D* from the projection screen, the size of the image on the screen would be $\frac{D}{d}$ times the actual size of the Stencil or, differently expressed, the magnification $M+M=\frac{D}{d}$. The magnification may be changed in two ways:

(a) By keeping the projection distance *D* constant and varying the distance between source and stencil.

(b) By keeping the distance *d* the same and varying the projection distance.

The illumination on the screen is more favorable with the shorter projection distance, because a greater amount of the radiation from the source is utilized. The illumination in the center of the field is inversely proportional to the square of the distance *D* of the screen from the source. For points outside of the center of the projection field the illumination is less than in the center. If *a* be the angle from the source to a point of the field distant the length *b* from the center, the illumination *i* at the point will be proportional to the cosine and the square of the sine of that angle and inversely proportional to the square of the distance from the center of the field to the point.

$$i=\frac{\cos a - \sin^2 a}{b^2}$$

To utilize more of the radiation from the source, we apply a condensing system, which takes in as large as possible a solid angle of the radiation from the source, and forms an image of this source at which the rays forming this image meet under a smaller angle or, more generally speaking, under an angle which is more suitable to the particular conditions of the case than the large angle of radiation taken in by the condenser.

By combining an optically perfect condenser, *i. e.*, a condenser which forms a point-shaped object, with a point-shaped source of great intensity, a very simple and perfect projection apparatus could be realized, which would need no projection lens and which would utilize a greater percentage of the energy radiating from the source than the condenserless arrangement. For example: In figure 2, *s* may be a point-shaped source and the distance between *s* and the condenser *c* may be shorter than the distance from the image of the source *s'* to *c*, so that the aperture of the condenser appears under a greater solid angle from the light source than from its image. If we assume

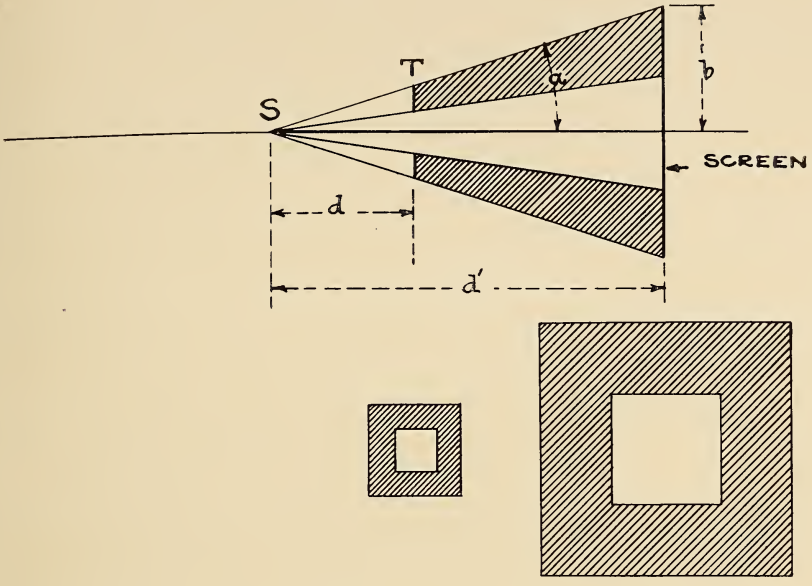


Fig. 1

Projection of the stencil T by means of a point shaped source S. The picture on the screen is the shadow of the stencil.

the geometrical conditions on the image side of the condenser (location of stencil, angle under which the boundary rays meet at the image s', projection distance, etc.) the same as the conditions in figure 1, we will have a perfected image of the same size for the same projection distance, but with better illumination, because a greater solid angle of the radiation is intercepted by the condenser and made useful for the projection than is intercepted by the stencil in figure 1.

The image s' can be considered in its effects like a real light source, with the difference that it radiates only within a limited solid angle, the apex of which is s' and whose base is the surface of the condenser.

The amount of radiation taken in by the condenser is proportionate to the square of the sine of the angle u between the optical axis and the ray through the margin of the condenser (which is half of the total angle taken in by the condenser). If, for instance, the size of the stencil in figure 1 were 3″ x 2¾″, the diagonal would be with close enough approximation=4″. Assuming a magnification of 10 at a projection distance of 113.4 inches, the resulting useful angle of radiation at the source would be 20°. If by using a condenser of suitable power, we intercept a larger angle of radiation while keeping the angle at the image the same, we will have an increase of illumination proportionate to the square of the sine of half the angle at the source. The amount of such possible increase may be seen from the following table:

Full angle $2u$ at source	Half angle u at source	sin u	sin $2u$
20°	10°	0.174	0.03
40°	20°	0.342	0.12
60°	30°	0.500	0.25
80°	40°	0.648	0.42
100°	50°	0.766	0.59
120°	60°	0.866	0.75

If we increase the angle u in our example from 10° to 20°, 30°, 40°, we shall have a relative illumination on the screen proportionate to 0.12, 0.25, 0.42 against 0.03, or taking the latter as unit, an increase of illumination of 4 times, 8.3 times, 14 times over the original case. This consideration does not take into account the loss by absorption and reflection in the passing through the condenser of the light.

Even though by use of the condenser we utilize a greater amount of

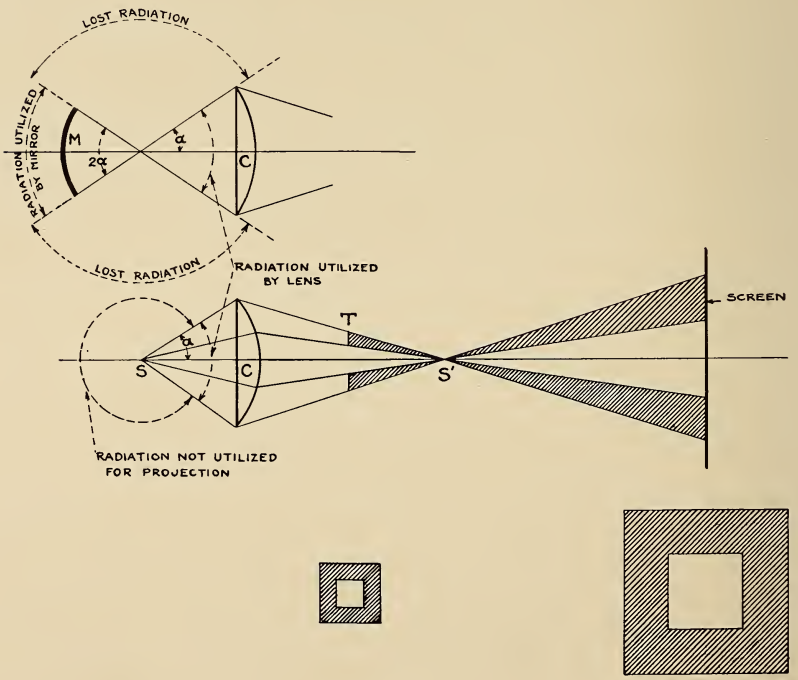


Fig. 2

By interposition of an optically perfect condenser C, the illumination on the screen can be increased, because a greater solid angle of the radiation from the source S is utilized for producing a picture on the screen of the same size as shown in Fig. 1. The upper figure shows how by placing a spherical mirror with its center curvature in coincidence with the light source, the quantity of light reaching the lens can, at least theoretically, be doubled.

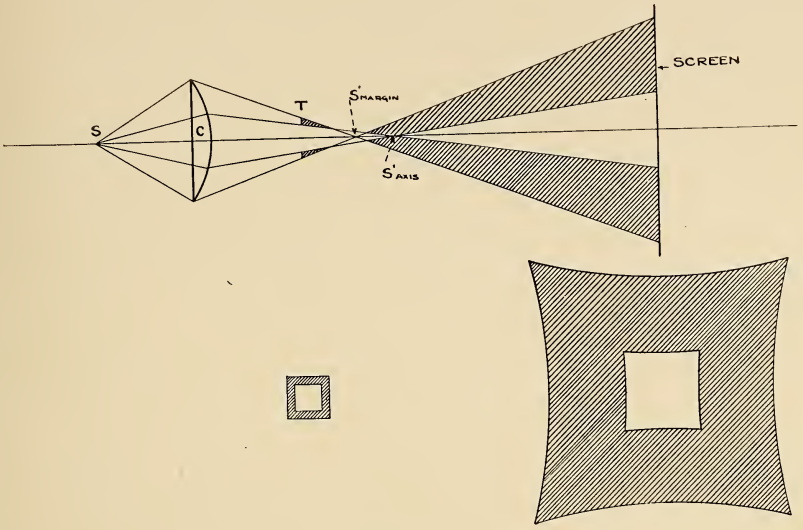


Fig. 3

Projection by means of a point shaped source and a spherically uncorrected condenser. The rays going through the margin of the condenser intersect the axis at S' margin nearer the lens and under a greater angle than those going through the lens near the axis which intersect the axis at S' axis. Parts nearer the margin of the object are imaged with higher magnification than those near the axis with the result that the picture on the screen shows cushion shaped distortion.

radiation than without it, we must be aware of the fact that the greatest part of the radiation from the source is lost as indicated in figure 2, because the radiation within the solid angle intercepted by the condenser is only a small portion of the total amount, which the source sends out in all directions. For optical reasons it is impossible to increase the diameter of the condenser very much beyond a size which takes in an angle of about 90 . The radiation within this angle can be increased considerably by placing a concave mirror behind the source so that its center of curvature lies in the source, figure 2. Assuming no loss of light by reflection on the mirror and by passing through the source the quantity of light reaching the condenser should be doubled by this expedient.

The conditions so far assumed do not exist in practice, because neither the condenser is optically perfect nor the source point shaped. We shall consider an

(a) Imperfect condenser in combination with a point shaped source, and understand by term imperfect nothing due to careless making of the condenser, but those imperfections in performance which are due to the nature of a simple lens system. These are spherical and chromatic aberrations. On account of the former, the different zones of the condenser will produce a series of images of the source; the nearer to the margin the zone, the nearer to the condenser the image produced by it, while with a spherically corrected condenser the rays from all the different zones of the condenser go through the same

point, or the hollow cones of light formed by the circumference of the zone as base line have the same apices. These cones have different apices with a spherically uncorrected condenser, the apices lying the nearer the condenser lens, the greater the diameter of the zone. The rays which pass through the margin of the condenser will, therefore, intersect the axis at 2: figure 3, under a greater angle than the corresponding rays in the arrangement with the perfect condenser. This increase of the angles will be small for rays passing near the center of the condenser and will become the greater the nearer to the margin of the lens the zone lies which produces the image. The effect is that the marginal parts of the field are imaged under a greater magnification than the center of the field. The image of a square object will show what is termed as cushion shaped distortion.

On account of the chromatic aberration, an uncorrected lens will produce images for the different colors composing the white light at the source at different distances from the condenser, the blue image

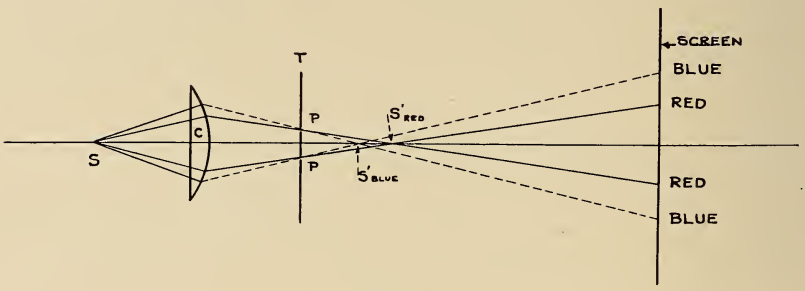


Fig. 4

Projection of a transparent point P of a stencil T by a chromatically not corrected condenser. The image of the source formed by the blue component of a white ray coming from the source and going through P lies nearer to the lens, at S' Blue than the image formed at S' Red by the red component of another white ray coming from the source. Therefore the blue image lies farther away from the center of the field, at "Blue," than the red image at "Red."

being nearest to the lens, the green, yellow, red, etc., lying at greater distances in the sequence given. For each color, therefore, an image will be produced in the same way as shown in the previous paragraph having spherical aberration and lying at different distances from the lens. We have to imagine the blue rays forming a cone of the same general shape as just shown, the green ones another one, a little more pointed, because the green image lies farther away from the lens, the red rays forming a still more pointed cone and so on. The precise shape of such a cone is further illustrated in figure 00. A point of a stencil interposed in this multitude of cones will be projected by the red, green, blue and so on rays at different places on the screen because these differently colored rays intersect the optical axis at different places and under different angles. Figure 4 shows how a white ray drawn to pass through the margin of the lens, the blue component, and of another white ray passing nearer to the axis, the red component goes through the transferred point P of the stencil. Figure 5 shows the projection of a transparent point of the stencil. The red ray pro-

jects the point at R (red) and blue ray at B (blue). The green and yellow images will lie between the red and blue ones, and in place of a white image we will have a series of colored ones forming a spectrum. The length of this spectrum is a minimum when the stencil is located near the condenser and increases as the stencil moves towards the image of the source. The amount of this chromatic aberration depends only upon the power of the lens, its aperture and the magnification under which the source is imaged; in other words, if the location of the source and its image with reference to the lens and the angle a are given, the amount of chromatic aberration is determined. The thickness of the lenses has no influence upon it. Consider:

(b) The case of a perfect condenser and an extended light source. If the image of the light source is not point-shaped, the multitude of rays passing through a transparent point in the stencil causes a spot of light on the screen instead of a point, the size and shape of which is determined by the rays drawn from the object point through the differ-

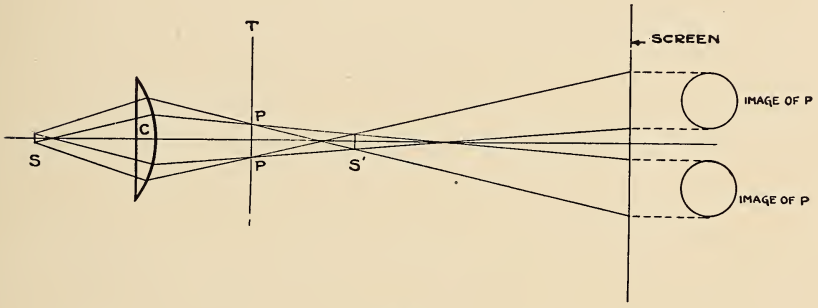


Fig. 5

Projection of a transparent point P of a stencil T with an optically perfect condenser and an extended source. The projection of the point on the screen is not point shaped, but a patch of light ("circle of confusion"), the size and shape of which depends largely upon the size and shape of the source.

ent points of the image of the source. The figure 6 shows how the rays forming the image of the source and crossing at the object point pass from the light source through different parts of the lens. The size of the spot of light on the screen which represents the projection of an object point will depend upon the size of the source, or its image, as well as upon the location of the object point between the condenser lens and image of source. Projection in this simple manner is possible only if the detail of the object is coarse in comparison with the size of the image of the source. For projection of detail of a minuteness beyond a certain limit, a projection lens will have to be applied as will be shown later. Consider:

(c) The usual case of an imperfect condenser in combination with an extended light source. Instead of having one image of the source, each zone of the condenser will produce an image of the source at a different place of the optical axis and for each color contained in the radiation from the source a different series of such images will be produced. The projection of the point takes place as described above

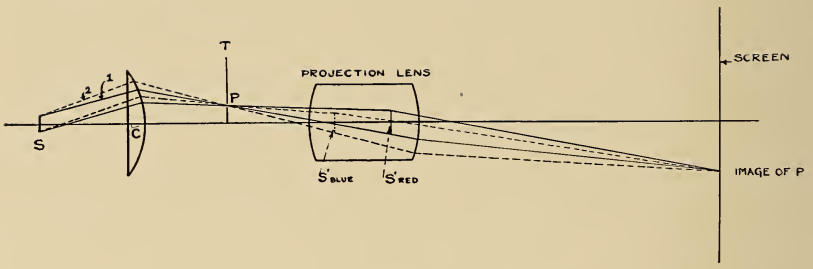


Fig. 6

Projection of a transparent point P of the stencil T by a projection lens in combination with an uncorrected condenser. Although the blue image of the source S' Blue and the red image S' Red are formed at different distances from the condenser C the projection lens reproduces a colorless image of P on the screen provided neither condenser nor projection lens are of sufficient size.

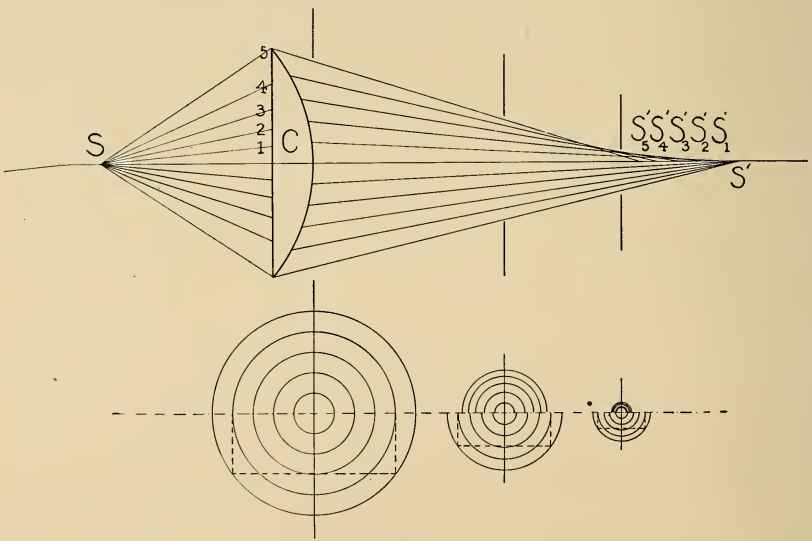


Fig. 7

Below the optical axis is shown the longitudinal section of a cone produced by a spherically corrected condenser, above the axis the section of a cone produced by a spherically not corrected condenser. While all zones of the spherically corrected condenser image the source S at S', the zones 1, 2, 3, 4, 5 of the uncorrected condenser produce images of the source at S_1' S_2', S_3', S_4' and S_5'. The three cross sections at different distances from the condenser allow a comparison of the distribution of light in these sections.

under (a and b) with the result that the light patch on the screen, the so-called circle of confusion, will have colored fringes, red towards, and blue away from the center of the field. The spherical aberration will add distortion to the image in the way explained above.

The patch of confused light which appears on the screen in place of the image of the object point caused by the size of the light source and by the chromatic aberration, can be converted into a true image of the object point by the interposition of a

(d) Projection Lens. Figure 6 shows the arrangement and also offers an explanation why in spite of the chromatic aberration of the condenser the image of the white object on the screen is white. We insert here that the image of the source must always fall in the aperture of the projection lens, which has to be large enough but need not be larger than necessary to pass all the radiation going from the condenser through the image of the source. The differently colored rays which intersect in the object point belong to white rays which fall upon different zones of the condenser lens. For instance, of the white ray from the source (1) a red component is refracted in the direction of the object point, while of a white ray (2) a blue component and of another white ray lying between (1) and (2) the green component leaves the condenser in the direction of an object point. This multitude of colored rays passing through the object point must, therefore, comprise all of the colors composing the light of the source and when gathered by the projecting lens and all brought to the same image point on the screen, form a white image of the object point. It is very evident also, that the image on the screen is white only if *all* the colored rays which may possibly go through the object point are united in the image on the screen. If, for instance, the diameter of the condensers were too small to pass the ray (2), the image would appear reddish yellow instead of white, because the blue is missing, or if the diameter of the projection lens were to be too small to let the red ray pass the image of the point would be bluish.

As long as we take care not to rob the pencil forming the image on the screen of any of its colored components, we shall have no difficulty on account of the chromatic aberration of the condenser. Of much greater influence is the effect of the spherical aberration. To obtain an even illumination of the screen, the section through the cone at the location of the stencil must be evenly illuminated. The cone of a perfect condenser offers sections with even distribution of light anywhere between the condenser lens and the image of the source—figure 7. There is a slight falling off of the illumination towards the margin for the same reason as stated at the beginning of this paper. A condenser which has spherical aberration will produce a cone in which the distribution of light is even only in sections near the condenser lens. The sections approaching the image of the source show a more and more increasing accumulation of light near the margin of the section because here the rays are more crowded together than in the central part of the field as may be seen in the figure. This is of no significance in lantern slide projection because the slide on account of its size is always located near the condenser, but very disturbing when, as in motion picture projection, the stencil is small and moved nearer to

the image of the source. If we place the stencil so that its diagonal is equal to the diameter of the cone, we shall have its corners in the marginal concentration of the light and, therefore, an uneven illumination of the stencil (see figure 7). To avoid this, the stencil has to be moved towards the condenser until its whole area lies in the evenly illuminated part of the cone. This means, of course, the loss of a very great percentage of light. The mere fact that a condenser has spherical aberration does not entail any loss of light if we are satisfied with an uneven illumination as long as the aperture of the projection lens is large enough to receive all the light passing through the image of the source. The sharpness of the image on the screen is not influenced by the spherical aberration of the condenser, if only the illuminating system is so centered that the image of the source, the spot, lies symmetrically to the center of the projection lens. If a slight decentration of the spot, without the spot getting outside of the aperture of the projection lens causes a deterioration of the image on the screen, the fault lies in the projection lens.

Another factor of influence upon the efficiency of a given combination of light source, condenser and projection lens is the size of the source and the location of the mat forming the border around the picture, the so-called aperture plate of the apparatus. The actual amount of light traveling from the condenser to the image of the source is embraced in a cone, the base of which is the condenser and the apex the image of the source. If the source is not point-shaped, the cone will be truncated.

We consider first a point-shaped source. If the stencil is of rectangular shape and its diagonal equal to the diameter of the light cone at the position of the stencil, the four segments of the illuminated source outside of the stencil do not contribute to the illumination. We shall refer to this in the following as diaphragm action (I). This is perfectly self-evident and there is no remedy for this loss unless we make the stencil circular. See figures of the half rectangles inscribed in the sections through the lower cone. Rectangular condensers have been suggested and are resuggested now and then, but instead of saving light, they cut out the unused light at a different plane of the optical system. They serve no purpose and are more expensive to make and to mount than the ordinary round condenser.

In case of a source of extended area the aperture plate does not only cut off these four segments, but also screens off parts of the condenser or of the light source in such a way that, while the radiation from the central parts of the source, which fills the condenser aperture, reaches the image of the source and, therefore, is utilized, the radiation from the extra axial points of the source, although it passes through the condenser, only partly reaches the image of the source and contributes to the illumination of the object point. We shall call this in the following diaphragm action (II.)

To simplify the drawings the light source and the aperture plate in the following are assumed to be circular. Figure 9 shows the path of the light rays from the center and from the two ends of the source as they pass through the condenser towards the image of the source s and s' are two conjugate points of the source and its image and the rays

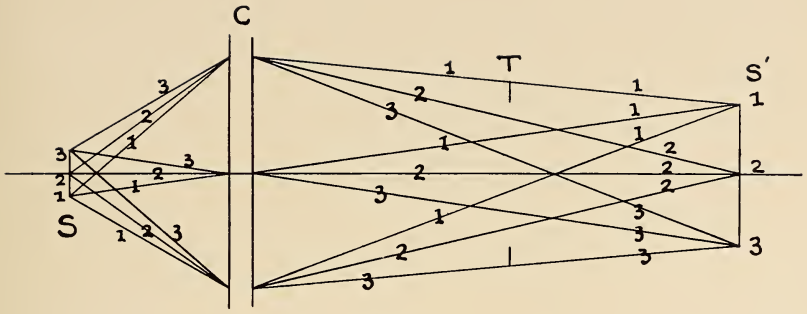


Fig. 9

Rays connecting the conjugate points 1, 2 and 3 of the source S and its image S'. From each of these points of the source a ray is drawn through center, upper and lower margin of the condenser C. The latter is represented here and in the two following diagrams by a pair of parallel lines.

connecting them are designated with the same figures (1), (2), (3).

Figure 10 illustrates how the ray from point 1 through the lower margin of the condenser does not reach the image point 1 and how the angle of useful radiation is smaller by the shaded portion than it would be were it not for the diaphragm action of the aperture plate.

Only the portions in the middle part of the source send forth cones which fill all the aperture of the condenser, while all the shaded parts of the pencils from points 1 and 3 are intercepted by the aperture plate as illustrated by the next drawing, figure 11.

We have to consider next the losses caused by

Absorption and reflection. The amount of light lost by absorption in a piece of glass depends upon the absorption coefficient of the material and on the thickness of the piece. The absorption coefficient varies from 1.3% per cm. for very clear glass to about 4% per cm. for very bad glass. The loss of light in a lens varies with the zones through which the light passes, depending on the different lengths of the path between the surfaces.

The loss by reflection depends upon the index of refraction of the

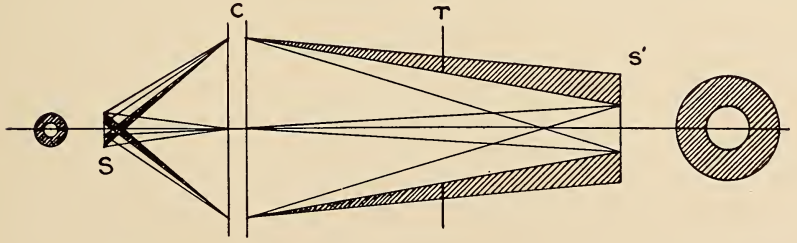


Fig. 10

The white circular areas at the right and left show the part of the image of the source imaged by the whole aperture of the condenser and the image of this part. The shaded anular zone around these circles represent the part of the radiation which is only partially by the condenser. The imperfect utilization of the area of the source is caused by the interposition of the aperture plate T.

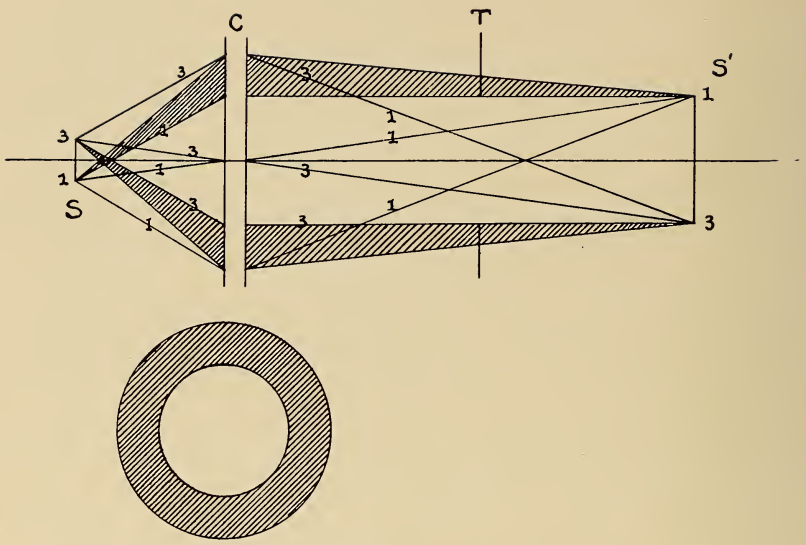


Fig. 11

Showing the part shaded of the solid angle of radiation from the ends of the source, which is diaphragmed by the aperture plate. The radiation from the ends of the source falling upon the shaded marginal zone of the condenser is not fully utilized on account of the diaphragm action (II) of the aperture plate.

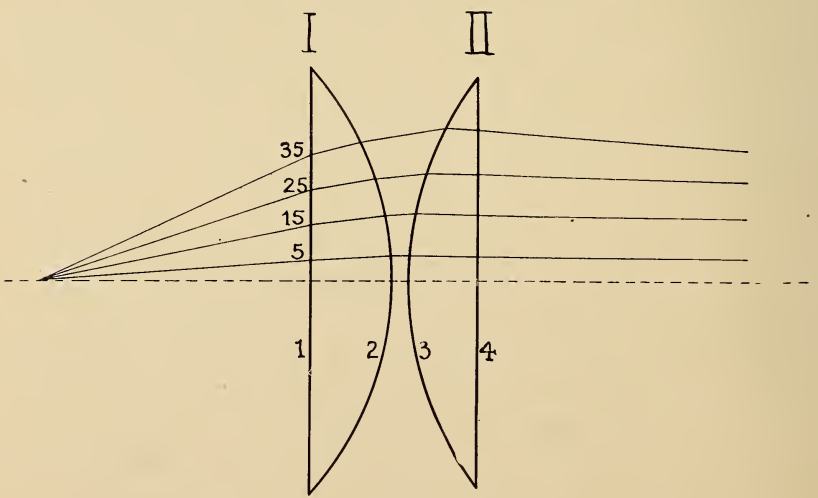


Fig. 12

The diaphragm shows the relative length of paths in an ordinary condenser through zones at a distance of 5, 15, 25 and 35 millimeters from the axis.

glass and upon the angle of incidence under which a ray strikes the surface. It increases, therefore, towards the margin of the condenser because the angles of incidence are greater there than nearer the center of the lens.

The following two tables show for 4 different zones of an ordinary M.P. condenser, the path lengths and the mean losses by absorption and refraction in these zones for the absorption coefficients 1.3% and 3.9% per cm., which are about the limit values for glasses available for this purpose. Figure 12 illustrates approximately the paths of the rays representing the middle of the zones through the condenser.

SPHERICAL DOUBLE CONDENSER

Absorption Coefficient 1.3% per cm.

Distance of center of zone from opt. axis	Loss in % by reflection on surface				Loss in % by absorption and length of path in lens in (mm)		Sum of losses %	Loss in % in zone
	1	2	3	4	I (22.5)	II (19.4)		
5	4.4	4.1	3.9	3.6	2.7 (21.7)	2.1 (18.0)	20.8	1.3
15	4.4	4.1	3.9	3.6	2.6 (18.4)	1.9 (15.0)	20.5	3.9
25	4.4	4.2	4.0	3.7	2.3 (14.9)	1.6 (9.7)	20.2	6.3
35	4.8	4.5	4.2	4.0	1.9	1.1	20.5	9.0

Total Loss 20.5%

Absorption Coefficient 3.9% per cm.

Distance of center of zone from opt. axis	Loss in % by reflection on surface				Loss in % by absorption and length of path in lens in (mm)		Sum of losses %	Loss in % in zone
	1	2	3	4	I (22.5)	II (19.4)		
5	4.2	3.8	3.7	3.3	8.2 (21.0)	5.9 (18.0)	29.3	1.8
15	4.4	3.8	3.7	3.3	7.7 (18.4)	5.5 (15.0)	28.4	5.3
25	4.4	3.9	3.8	3.5	6.9 (14.9)	4.7 (9.7)	27.2	8.5
35	4.8	4.3	4.1	3.7	5.5	3.2	25.6	11.2

Total Loss 26.8%

The same is done in the next two tables for a Fresnel lens, which is spherically corrected, has only 2 reflecting surfaces, less glass path, but higher angles of incidence in the outer zones. The average glass path is here the same for all zones and equals 10 mm.

FRESNEL LENS

Absorption Coefficient 1.3% per cm.

Distance of center of zone from opt. axis	Loss in % by reflection on surface		Loss in % by absorption and length of path in lens in (mm)	Sum of losses %	Loss in % in zone
	1	2			
			(10.0)		
7.1	4.3	4.1	1.2	9.7	1.1
			(10.0)		
22.0	4.8	4.5	1.2	10.5	2.8
			(10.0)		
29.8	6.0	4.5	1.2	11.7	3.3
			(10.0)		
37.6	9.0	4.5	1.2	14.7	5.0

Total Loss 12.2%

Absorption Coefficient 3.9% per cm.

Distance of center of zone from opt. axis	Loss in % by reflection on surface		Loss in % by absorption and length of path in lens in (mm)	Sum of losses %	Loss in % in zone
	1	2			
			(10.0)		
7.1	4.3	3.9	3.8	12.0	1.4
			(10.0)		
22.0	4.8	4.3	3.5	12.8	3.4
			(10.0)		
29.8	6.0	4.3	3.7	14.0	3.9
			(10.0)		
37.1	9.0	4.3	3.6	16.9	5.8

Total Loss 14.5%

Loss of light on a concave silvered glass mirror as used behind the light source is caused

(a) By the reflection of the in and out going ray on the outside surface, which amounts to about 8%,

(b) By reflection on the silver film, which varies considerably with the quality of silvering, 10% being an average figure, and

(c) By the absorption in the glass which amounts to from 1% to 4% for a mirror of 5 mm. thickness.

These figures add up to a total loss of about 20% on the mirror. If photometric measurements show in general a greater loss up to 50% in commercial mirrors, the reason may be found in most cases in the poor silvering and bad conditions of the surfaces.

In the case of a double condenser about 73% to 80% of the light contained in the angle $2u$ reaches the image of the source after having passed through the condenser. Of the 80% which in the best case is reflected by the spherical mirror, 20% to 27% are lost by passing the condenser so that the total amount which reaches the image of the source equals in the best case 80% + 64%, or 1.44 times the amount contained in the angle $2u$. If the higher figure for the loss in the condenser is taken, the total is reduced to 73% + 58% or 1.31.

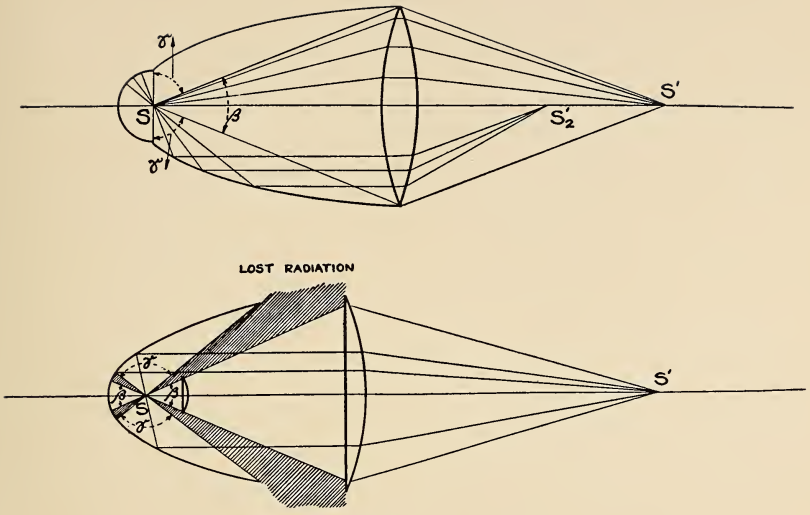


Fig. 13
Upper diagram: Petzval's Katadioptric Condenser.
Lower Diagram: Adaptation of an automobile headlight to a M.P. condenser

In case of a single condenser the corresponding figures will be 1.58 and 1.53.

The question may now be raised what, is the best result obtainable at the present state of the art and in which directions may improvements be made.

We found the following factors of influence upon the efficiency of the condenser system:

(1) Radiation from the source not intercepted by the optical system and, therefore, lost;

(2) Spherical aberration of the condenser;

(3) Chromatic aberration of the condenser;

(4) Diaphragm action (I) of the aperture plate on account of the rectangular shape of the opening;

(5) Diaphragm action (II) of the aperture plate on account of its location when the light source is not point-shaped;

(6) Absorption and reflection.

Of these the influence of (3) and (6) can be shortly dealt with. Chromatic aberration causes no loss of light in a properly designed system, while the loss by absorption and reflection which amounts to from 12% to 15% in single lens condensers and to 20% to 27% in doublets is absolutely unavoidable.

The loss due to the rectangular shape of the stencil, diaphragm action (I), cannot be avoided even by employing an optically perfect condenser and a point-shaped source and so there remain for consideration only the utilization of the radiation not intercepted by the condenser lens, the spherical aberration and the diaphragm action (II) of the aperture plate when the source is not point-shaped.

The utilization of the radiation not intercepted by the lens was attempted many years ago. About 1840, Prof. Petzval described a construction which I feel should be given the publicity it deserves, because it marks the limit of what can be accomplished in this direction. I was not able to refer to Petzval's original description and had to use a diagram in Hugo Schroeder's Elemente der Photographischen Optik. There is no interpretation of the diagram given and if the following should not do justice to the construction, I have to apologize to Prof. Petzval. In figure 13, s is the source placed in the center of curvature of a hemispherical mirror, which throws all the light radiating in the direction away from the condenser back into the source. At its equator the hemispherical mirror is joined coaxially by a paraboloid which collects the rays of the solid angle B and sends them in a direction nearly parallel to the optical axis towards the condenser lens which forms an image of the source at s'. All the light radiation within the solid angle B passes after reflection by the mirror through the condenser lens to the image point s' while the light radiating in the remaining solid angle d passes through the condenser lens directly, forming another image of the source at s'. The drawback of the construction lies in the technical difficulty of producing a perfect paraboloid and joining the two mirrors so that no shadow is cast within the cone and in the fact that two images of the source are produced. A paraboloid with badly-formed surface and also a decentration of the two mirrors are apt to cause uneven distribution of light in the cone even when the stencil is located near the lens. This apparatus may work well when used for lantern slide projection, but hardly for M.P. projection. Whether its efficiency is greatly superior to a good condenser made up of lenses in the usual way is somewhat doubtful if we consider the loss by reflection on the parabolic mirror and the fact that the greater part of the radiation is reflected by the hemisphere and then reflected by the parabolic mirror and, therefore, will suffer this loss twice.

Because of the similarity with Petzval's construction, we may mention here another one, which has been quite in vogue as an automobile headlight a few years ago and which is almost identical with the proposal made by Mr. Jenkins at the Rochester meeting in April, 1918. It contains (Fig. 13) a small condenser in whose focal point the source is placed and the usual arrangement of the concave mirror. The angle taken in by the condenser B and which is, at least, geometrically speaking, doubled by the mirror, amounts to about 50 degrees. This is thrown forward by the condenser in a beam of parallel rays by the condenser. A paraboloidal reflector is joined coaxially with the spherical mirror, so that its focal point coincides with the focal point of the lens and the center of curvature of the spherical mirror. This paraboloid intercepts the greater part of the radiation which is not used by the lens and spherical mirror and like the condenser lens, projects it forward in a parallel beam. By adding a condenser lens of the diameter of the reflector, an image can be formed of the source not far from the condenser and the combination be used for projection work. A similar effect can be produced by moving the source and the center of the spherical mirror outside of the paraboloid

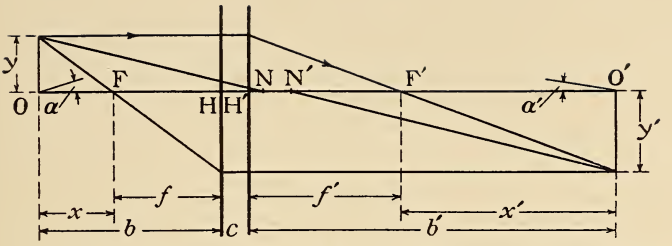


Fig. 1
An object y, imaged by an optical system represented by the principal points H and H′, the nodel points N and N′, and the focal points F and F′.

$$x.\ x' = f.\ f'$$

$$\frac{\mathrm{d}\,x'}{\mathrm{d}\,x} = -\frac{f.\,f'}{x^2} = -\frac{x'}{x} = \mathsf{X}$$

$$\frac{y'}{y} = \frac{f}{x} = \frac{x'}{f'} = \mathsf{Y}$$

$$\frac{\tan\alpha'}{\tan\alpha} = -\frac{x}{f'} = -\frac{f}{x'} = \mathsf{A}$$

$$y'\,n'\tan\alpha' = y\,n\tan\alpha$$

$$\mathsf{Y\,A} = \frac{n}{n'} = \frac{f}{f'}$$

$$\frac{\mathsf{X\,A}}{\mathsf{Y}} = 1$$

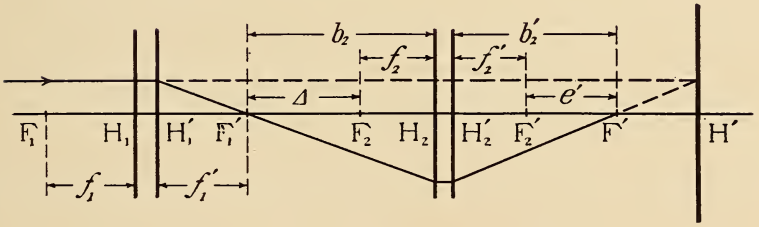


Fig. 2
A compound system composed of two elements represented by the principal points H_1, H_1' and H_2, H_2', and by the focal points F_1, F_1' and F_2, F_2', the distance F_1', F_2 being the optical interval Δ; object point at $-\infty$

$$f' = \frac{f_1'\,f_2}{\Delta} \qquad f = -\frac{f_1\,f_2'}{\Delta}$$

$$e' = -\frac{f_2.\,f_2'}{\Delta} \qquad e = \frac{f_1\,f_1'}{\Delta}$$

$$f' = b' \text{ because } u = \infty$$

and the condenser. The shape of the reflector should, however, be ellipsoidal in this case to prevent spherical aberration, which on account of the large angles of incidence near the margin of the reflector may reach enormous amounts. The combination produces one image of the source only when the focal points of the condenser and paraboloid coincide. Efficiency of this construction when used as motion picture condenser exists, probably, not even on paper. The spherical aberration can be partly avoided. Although inspection of Mr. Jenkins diagram shows uneven distribution of light, the effect of the great angle intercepted by the paraboloid is mostly offset by the loss of light on account of the very unfavorable angles under which the light is reflected, especially in the outer parts of the reflector. The centering of such a combination upon a common optical axis is not at all an easy matter, and the lack of centering will cause a one-sided, uneven distribution of light.

The spherical mirror behind the source is undoubtedly a valuable addition. It dates back to the early days of the magic lantern. I used it in 1908, in an apparatus for the projection of compass readings on ships in combination with an incandescent lamp. The filament in these lamps, which were made by the Westinghouse Electric Co., was of grid form and resembled a very steep "M" with rounded corners, over which the image superimposed itself like a "W", so that no screening of the image by the source took place, except in one point at each bend. The device was patented.

In 1917, the General Electric Co. secured a patent on a modification of this arrangement, limiting it to a parallel coil grid filament, "the area of the spaces between the coils" being equal to the "effective light emitting area of the grid coils," which is the form now so frequently used.

As mentioned above, the gain by the use of the mirror behind the source amounts to 50 to 75 per cent.

The influence of the spherical aberration can be offset by placing the stencil near the condenser, which is equivalent to a lantern slide arrangement in reduced size. While the condenser could be of the most common kind, it would be necessary to place the source nearer the condenser, than so far has been feasible at least with sources of considerable area. There would be no loss by diaphragm action (II) of the aperture plate. The condenser could, however, not be of the Fresnel type, otherwise the circles separating the zones would be projected into the image as shadows.

A condenser without spherical aberration has the advantage that the stencil may be placed anywhere in the cone, except in a condenser of the Fresnel type, where location near the condenser has to be avoided because of the shadows cast by the rings between the zones.

If the light source is point-shaped, no diaphragm action (II) by the aperture plate will occur wherever the latter may be placed. Diaphragm action (II) by the aperture plate will occur as soon as the light source has an extended area and as soon as the stencil is placed at a distance from the condenser.

A condenser without spherical correction, combined as usual with an extended source, is the least efficient combination, because of the

position of the stencil necessitated by the uneven illumination of the cone and the resulting diaphragm action (II) of the aperture plate.

Bearing in mind, that the concave mirror renders the same service in all cases and that the condenser which is composed of the smaller number of elements is preferable and that the stencil is located in the smallest section of the cone where it is evenly illuminated we sum up the different possibilities in the sequence of their efficiency.

(1) Small ordinary condenser, source not too large and near the condenser, stencil near the condenser, large projection lens.

Practical difficulties: the light source. Faults: none.

(2) Just as good: large spherically corrected condenser, point-shaped source at usual distance from condenser, stencil not near the condenser, small projection lens.

Practical difficulties: the light source. Faults: none.

(3) Spherically corrected condenser, extended light source at usual distance from condenser, stencil not near the condenser, large projection lens.

Practical difficulties: none. Faults: loss by diaphragm action (II) of the aperture plate.

(4) Large ordinary condenser, extended light source at usual distance from condenser, stencil not near condenser, large projection lens.

Practical difficulties: none. Faults: loss by spherical aberration and diaphragm action (II) of the aperture plate.

The nearer point-shaped the light source, the lower grade a projection lens may be used.

SPROCKET TEETH AND FILM PERFORATIONS AND THEIR RELATIONSHIP TO BETTER PROJECTION

By A. C. Roebuck

Among the further subjects that merit carefulattention by the Society of Motion Picture Engineers, there are probably none that present greater possibilities than those that may lead to the elimination of as much as is practicable of the unsteadiness or jumping of the picture on the screen.

It was prior to 1900, I believe, that means for the prevention of the side vibration of the film became a question of importance. The first effort toward the elimination of this objectionable feature was the use of a guide for the edges of the film, the guide for one edge being made flexible, but this plan was found to fall short of expectations and it never came into general use.

To undertake to guide the film accurately by the sprocket teeth was not possible at that time because of the wide variety in the sizes and forms of film perforations in use. Film perforators in the early days were mostly made under the direction of the maker of the films and there was apparently no effort made toward the standardization of the perforations. The length and width (especially the length) of the perforations and the distance between centers across the width of the film were different with each manufacturer, and it was found as late as 1906, I believe, that one manufacturer used at least five different forms of perforations. I believe the first perforations were rectangular in form with slightly rounded corners. Later the present type of perforation with circular ends was introduced, as I remember it, by Pathé Bros., of Paris, France, and this type of perforation has gradually grown in favor until it is now almost universally used.

The former perforations of varying lengths and widths and of varying distances between the centers of the perforations across the width of the film, placed the manufacturers of projecting machines at a great disadvantage, not only in being unable to use the sprocket teeth as a guide to prevent side vibration of the film, but also the wearing qualities of both the sprocket teeth and the film were reduced because of the teeth having to be made so much shorter than otherwise would have been possible.

Now that the general use of a standard film perforation is apparently a near future possibility, it seems it will be possible to use the teeth on one end of the sprocket wheel as a guide to prevent side shake by making them wide enough to fit the length of the perforation as is being done by at least one of the manufacturers of film printing machinery. To obtain the best results, this plan would require that the teeth must be properly formed, not only on the ends, but on their sides from base to point in order to give the film proper clearance as it engages and leaves the teeth.

Owing to the shrinkage in the film due to the elimination of moisture, especially while new, together with its expansion and contraction

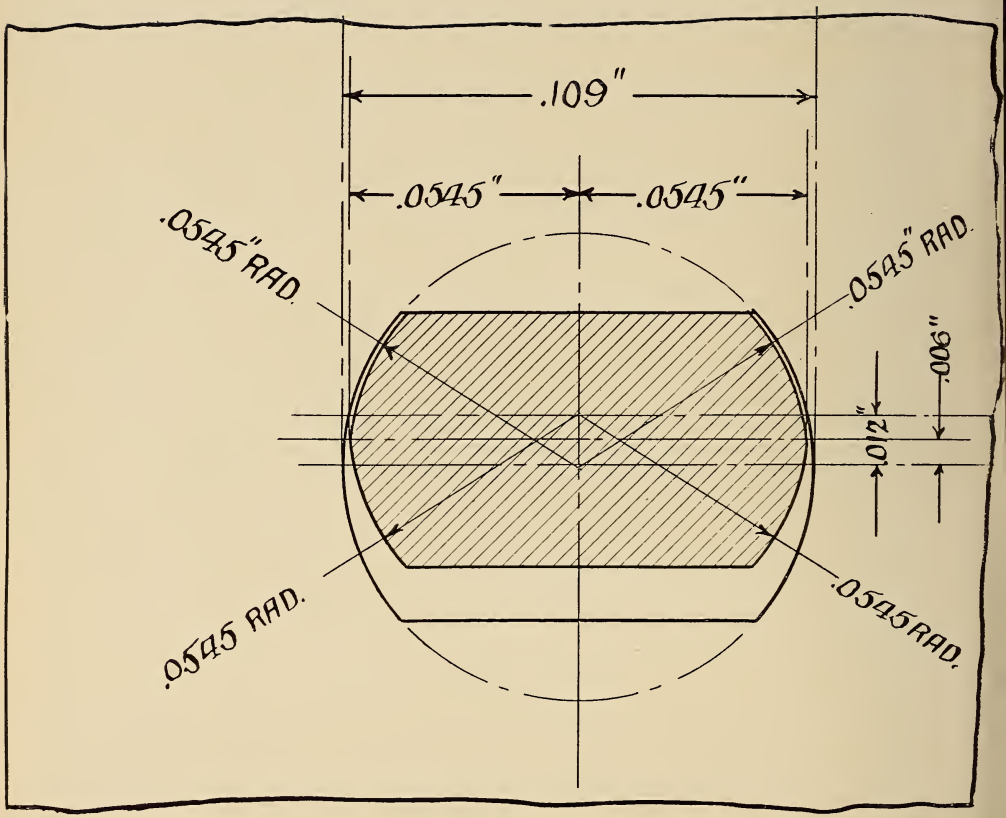


FIG. 1
Film perforations from Book of Standards.

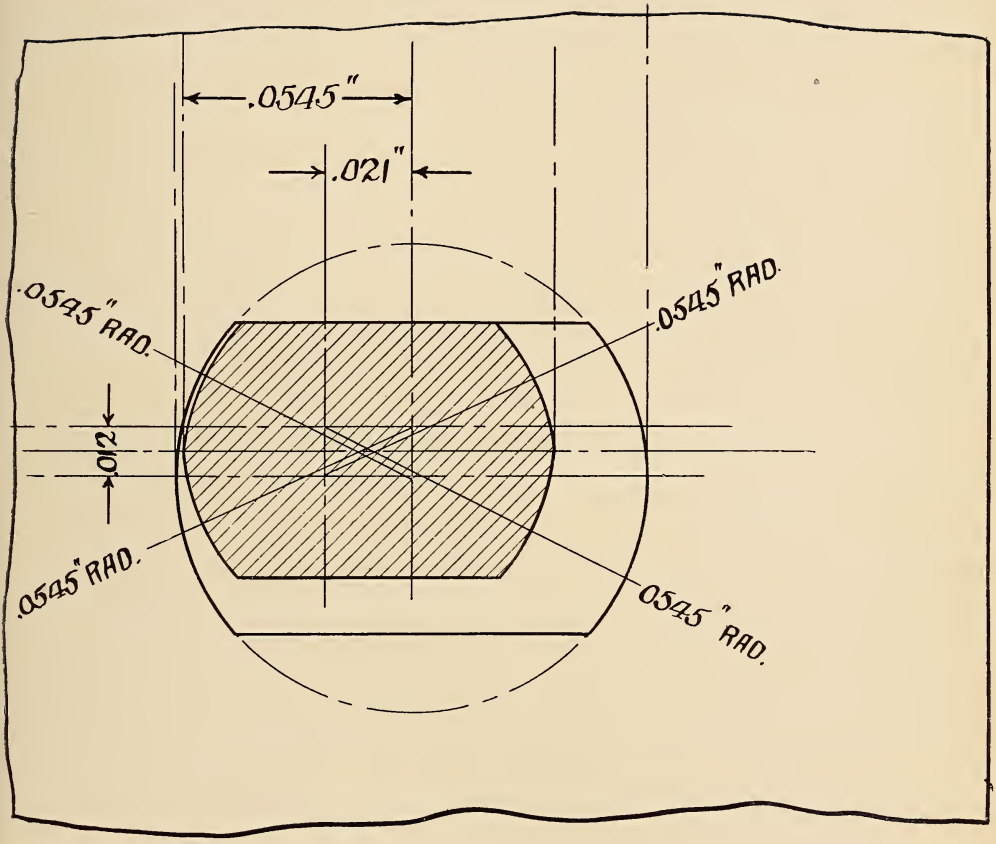


Fig. 1
Film perforations from Book of Standards.

from time to time due to atmospheric changes and moisture treatment it is not practicable to undertake to guide the film by having the teeth on both sides of the sprocket wheel the same length as the perforations in the film. Therefore, it seems necessary to make the teeth on one side of the sprocket wheel to fit closely the length of the film perforation and then shorten the tooth on the opposite side sufficiently to allow ample freedom for expansion and contraction in the width of the film.

At a recent meeting of the Society, the consideration that preceded the adoption of a standard for film perforation presented some complications because of the expected future relationship between the film perforation and the form and size of the sprocket tooth, and of finding a practical means for producing the film sprockets. It was the belief of some of those present that the use of a film perforation with circular ends would present complications in the forming of the sproc-

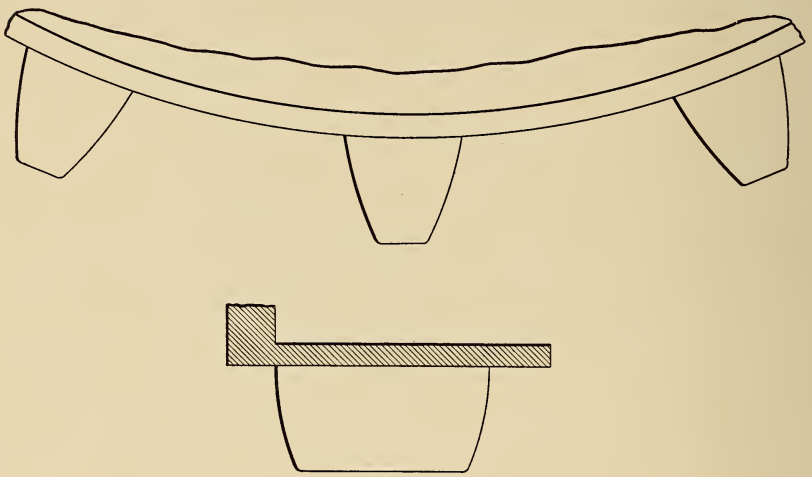


FIG. 2
Side and end view of sprocket tooth.

ket teeth to fit the perforations that might be so great the plan would not be practical, and that teeth made to fit a rectangular perforation with rounded corners would eliminate the complications in manufacturing, make it possible to grind both the ends and the sides of the sprocket teeth, thus correcting both the alignment and the spacing of the teeth, and would make it possible to secure the greatest degree of accuracy in the projection of the picture on the screen.

Mr. Bell of the Bell & Howell Company of Chicago, stated that for several years past they have been using on their film printers, sprocket wheels with teeth on one end made to fit the perforations in the film to prevent side movement, while the teeth on the other end of the sprocket wheel are made shorter. This plan has been possible with them because usually the film manufacturer who uses their goods adopts their equipment complete including film perforators, cameras,

printers, etc. Mr. Bell said they have been "forming" the teeth of the sprockets for their film printers, but that the method they are using for "forming" the teeth would probably not give satisfactory results in the production of a sprocket wheel of small diameter, such as is used for projection work. He said, however, they have given some thought to a method of "generating" the teeth that would be suitable for the production of sprocket teeth on a commercial basis with a sufficient degree of accuracy for practical purposes, and having in mind the present almost universal use of the film perforations with the circular ends, and the almost unsurmountable difficulties in the way of undertaking to get the manufacturers to change the form of tooth they are at pres-

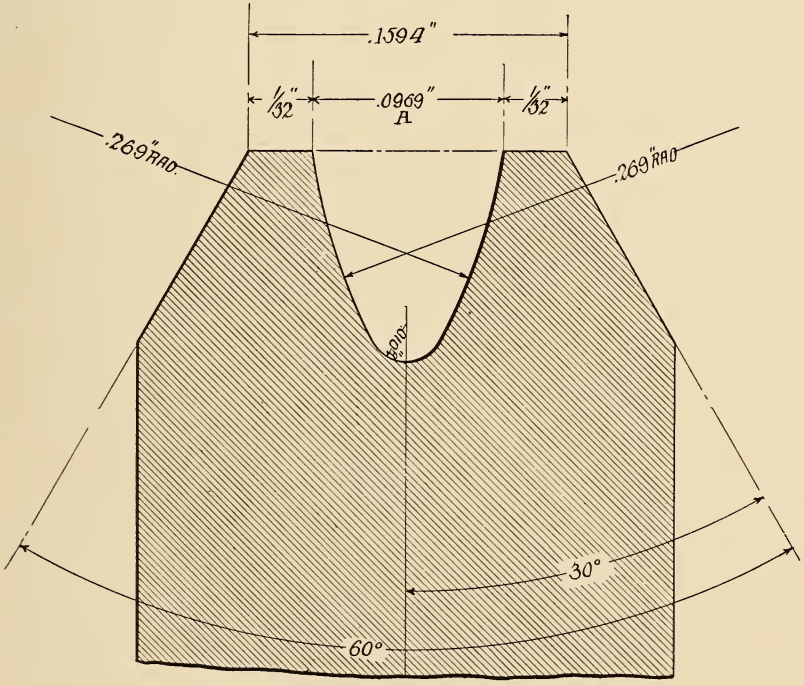


Fig. 3
Sectional plan view showing teeth and film perforations.

ent using, largely because of the great amount of expense involved in changing their machinery, cameras, etc., the Society thought best to adopt the film perforation with the circular ends with the understanding that in taking such action it would not necessarily be definite and could be changed at some future date in case developments should come about that would make a change advisable.

A diagram showing a strip of film with perforations, measurements, etc., adopted as a standard by the Society, appears in the latest issue of the book of standards, a copy of which is here reproduced.

Through the courtesy of Mr. Howell, I have secured blueprints

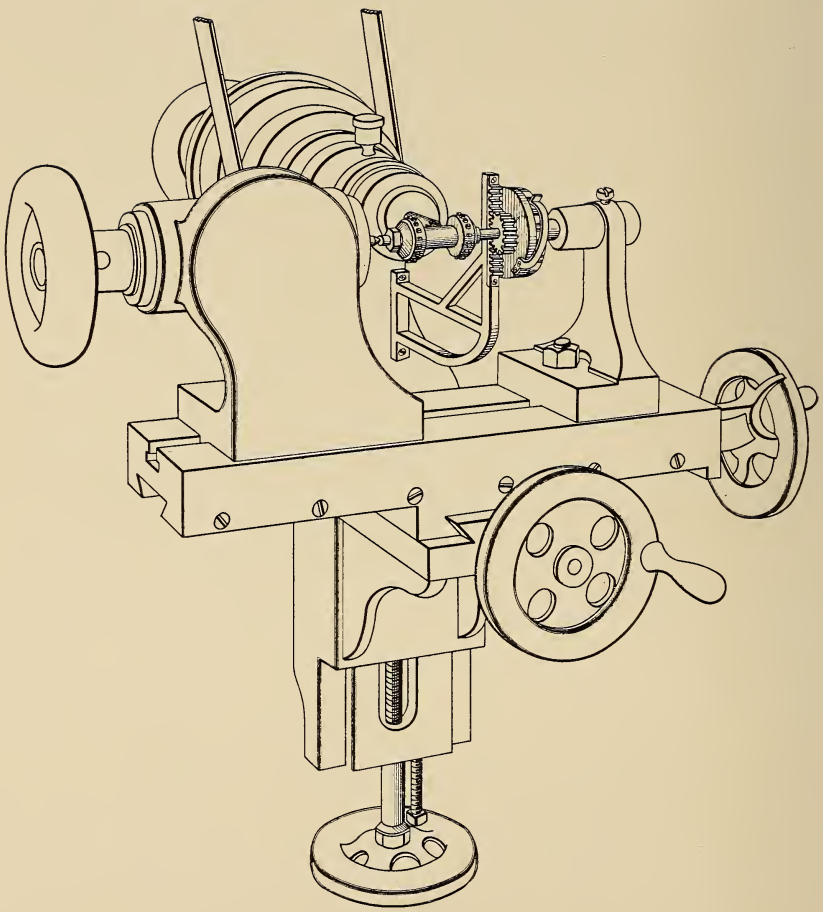


FIG. 5
Gear cutting device mounted on lathe for tooth generating operation.

showing the tooth with formed circular ends that is now being used in their film printers, and also showing the method used by them in forming the teeth to fit the perforations in the film. While satisfactory for forming the teeth on the large size sprocket used in their film printer, the process as previously stated would be objectionable for a sprocket wheel of approximately one inch in diameter as used in the projector, because at the base of the corners of the teeth an unfinished projection would remain, unless at the ends of the teeth the cutter would be advanced to the point where the flange of the wheel would be recessed to an extent that would be objectionable.

In making the teeth with ends formed by their present process, as shown in the accompanying drawings, a hollow mill or forming cutter is used. The mill operates through a bushing to center it, for the prevention of vibration and to make it possible to cut on only one side of the center. The sprocket wheel should be indexed for each tooth

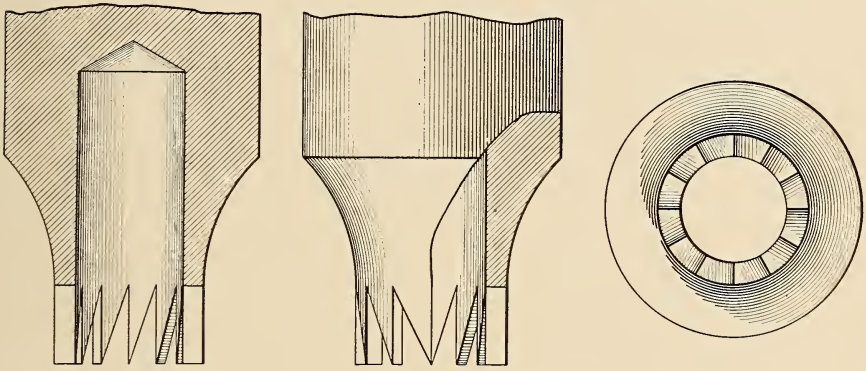


Fig. 4
Forming cutter with conical opening.

the same as in the regular operation of cutting the teeth on a gear cutter. The opening in the end of the cutter used for forming the teeth is made conical to fit the form of the tooth, as shown in Fig. 4.

As the width of the teeth are made less than the width of the perforation, the ends of the teeth are milled on one side of the center and then the sprocket is indexed .012 of an inch and the ends are milled on the other side of the center.

As a means for "generating" the teeth for use in a projecting machine, Mr. Howell has advanced the following theory, which as I understand it, has not been demonstrated to the point of determining definitely that it is practicable, but it seems to present encouraging possibilities. In this as in the preceding process, a hollow end mill type of forming cutter is used, the opening in the end of the former being cylindrical instead of conical as in the preceding form of cutter.

The hollow end mill for this process may be mounted in the spindle of a bench lathe, the cutting end being supported preferably in a bushing, while the sprocket wheel together with its index may be carried on a gear cutting attachment for the bench lathe. To perform the "gen-

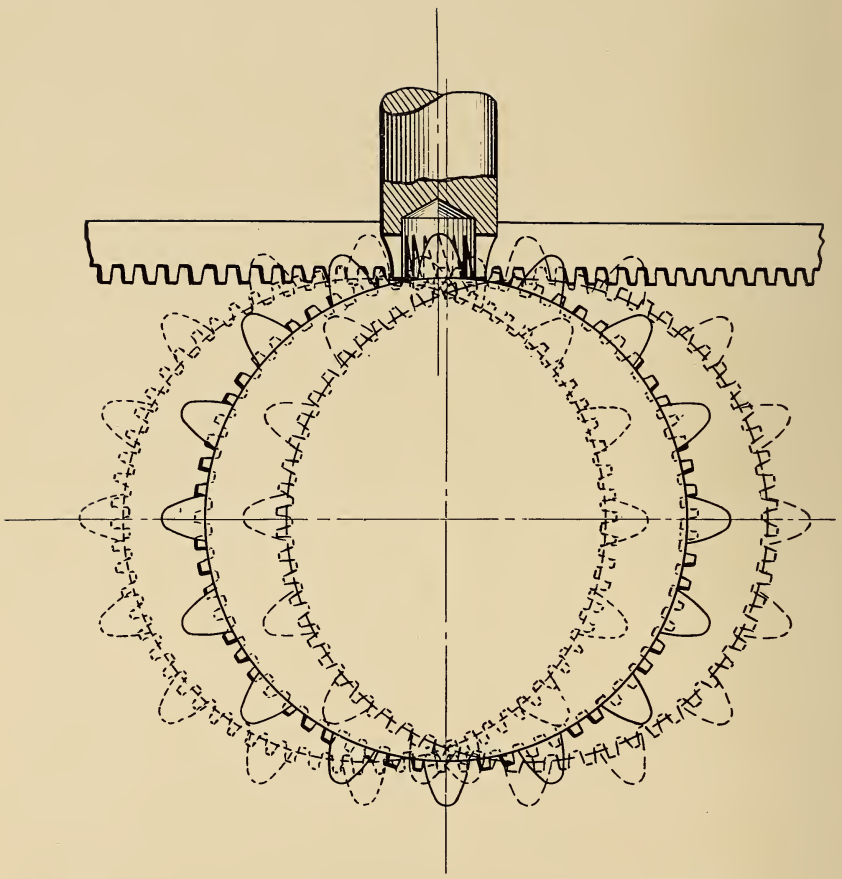


FIG. 7
Sprocket wheel in three positions with relation to the cutter.

erating" operation, it would be necessary to provide a rack and pinion movement, the rack being attached to the body or head of the lathe and the pinion loosely mounted on the spindle that carries the sprocket wheel. An index disc should be attached firmly on the shaft that carries the sprocket wheel, the index being used for the purpose of changing the relationship between the sprocket wheel and the pinion. The pitch diameter of this pinion should be equal to the diameter of the sprocket wheel plus one-half the thickness of the film. The rack should be placed on the same side of the gear as the end mill for forming the teeth. Thus, the pitch line of the rack and gear would be the same as the pitch line of the film and the sprocket teeth.

It would be necessary to eliminate from the rack and pinion connection all possibility of lost motion and for this purpose it is probable that a double rack, adjustable endwise, such as is used on profiling machines, would be desirable for the purpose.

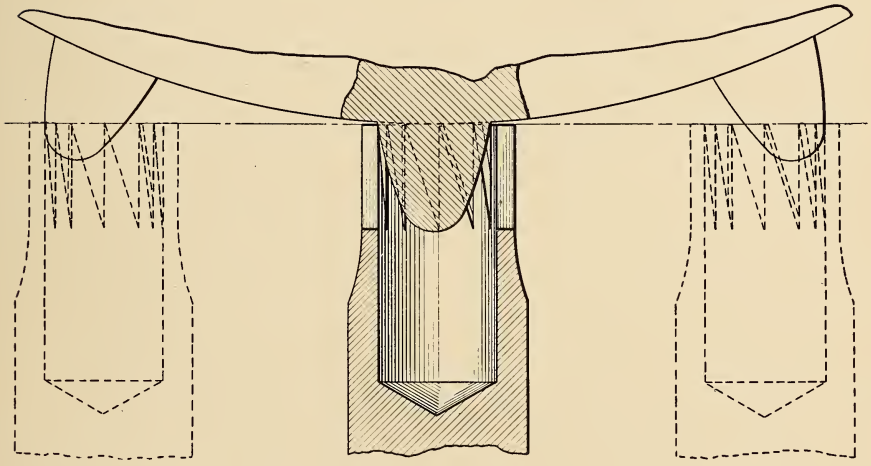


FIG. 8

Enlarged view of tooth and cutter only, with tooth in section, and on a line near the end of the tooth where it comes in contact with the matter.

It will be seen by the accompanying sketch that when the carrier of the sprocket tooth is moved up or down the connection of the gear with the rack will give the sprocket a rolling movement, and if the sprocket wheel and tooth are positioned so that when the center of the sprocket shaft reaches a point on a line horizontal with the center of the forming cutter, and the center of the sprocket tooth will at that time also be in the same line, the rolling motion given to the sprocket tooth as it enters and leaves the opening in the cutter will apparently form the tooth in accordance with the requirements.

It has been my opinion, and I believe it is generally agreed, that the best results can be obtained by the use of rectangular perforations because in that case after rounding the corners of the teeth with a forming cutter, the sides and ends of the teeth could be ground. This too

would apparently make it practicable to harden the sprocket wheels and then correct the distortion from hardening by grinding, whereas it would seem that the method of generating the teeth with a forming cutter as previously described, permits the making of soft sprockets only, the form of the teeth of which quickly change through wear. It may be that some method might be devised for the use of a forming grinder having a small hollow grinding wheel, such as a lap of tough metal and charged with abrasive material to revolve around the tooth as the sprocket wheel is fed past the grinding attachment, but it is probable such a plan would not be practical.

In presenting this method as a means of generating the sprocket teeth, I wish it understood that I am not in a position to vouch for it in that it is a theory that has not been proven. I have endeavored to present it as nearly as possible as it was explained to me, having myself added the suggestion for the use of the double rack as a means of eliminating the lost motion. It would seem, however, that it presents promising possibilities as the only practical method whereby we may expect under present conditions to be able to guide the film to prevent side movement, and it is to be hoped that it may lead to practical results and ultimately result in the adoption of a standard that will add substantially to further accuracy and efficiency in film projection.

Discussion

Following the paper, the chairman opened the discussion by emphasizing the necessity of the grinding operation. He also brought out, that the grinding operation might be limited to simply bevelling off the corners. Mr. Roebuck objected that this would leave a corner which would be dangerous to the film.

Along the line of grinding, Mr. Mayer suggested that the question of suitable grinding material could be easily handled, citing the Chemical Exposition at New York where a number of various moulded abrasive materials were shown.

Mr. Roebuck brought up another possibility, that of using a hollow grinding tool instead of a hollow mill, providing proper feeding could be arranged.

Here the discussion digressed to the question of the relative motion of the sprocket and cutter, Messrs. Mayer, Roebuck, Cook and the chairman taking part.

Mr. Roebuck brought back the discussion to the question of feeding a grinding tool to take care of the wear of the abrasive and suggested a method. Mr. Richardson objected that this would not be accurate, at least from the standpoint of production. Mr. Roebuck said that it would be practical from the mechanical point of view. Mr. Richardson added that it would be all right if the grinding proposition were taken care of as an additional operation, but doubted the accuracy if the sprocket were generated by grinding. Short discussion on the accuracy question by Mr. Richardson and Mr. Roebuck followed.

Mr. Victor offered a suggestion of generating by the use of a hollow tapered grinder or cutter and rocking the sprocket. This would approximate the generated tooth and would be accurate enough for practical purposes. Mr. St. John approved Mr. Victor's suggestion.

Mr. De Vry objected that the cutter would soon deform. Mr. Victor took care of his objection.

Mr. Roebuck concluded the discussion by emphasizing the practicability of accuracy with low cost. He told of an automatic machine which he saw at the Chicago World's Fair, which made the barrel arbor in a watch movement. He illustrated by a sketch on the blackboard what the arbor is, and the fact that it must be accurate enough to be interchangeable within all watch movements of that make. This machine was doing the several operations necessary automatically and yet with sufficient accuracy, that the finished pieces cost the trade only about 30 cents apiece.

FUNDAMENTALS OF ILLUMINATION IN MOTION PICTURE PROJECTION

By R. P. Burrows

A paper presented before this Society entitled "Light Intensities for Motion Picture Projection" called attention to the many factors which enter into the determination of a suitable light intensity for the motion picture screen. Since this paper was presented, experience in the motion picture industry has shown the necessity of bringing to the attention of those interested in the development of the industry, through motion picture journals, conventions such as this, and through personal contact, a conception of the fundamentals of illumination measurement.

In reviewing the Transactions of this Society and the handbooks on projection, it is found that serious attention has not been given to light measurement. It seems desirable at this time to present material in a simple form which can be used as a basis for educational work which it seems to me this Society should do to help eliminate the guesswork from motion picture projection.

Comparisons of the candlepower of arc lamps when employing right angle carbons, inclined carbons, various sizes of carbons, various ampere strengths, etc., etc., are interesting and very instructive from certain standpoints, but the one result in which the projectionist is chiefly interested is the brightness of the picture to the eye of the observer. It is readily apparent that because of differences in the optical systems, differences in the reflection characteristics of various screens, differences in the fineness of adjustment, etc., two sources of very different candlepower might give equal results so far as the spectators are concerned.

To obtain a true comparison of the results obtained with different systems, it is necessary to use units of measurement which are not familiar to the motion picture industry. Just as we once had to learn that there is a unit called the yard which is used to measure length, that the gallon is a unit used to measure quantity and contains 231 cubic inches, so in dealing with screen intensities certain fundamental units must be studied before measurements can be made and before definite relations of cause and effect can be comprehended or expressed. Basic definitions have a very academic and sometimes a very technical sound, although the units themselves, once their definitions have been assimilated, and not merely learned by rote, are comparatively simple. The definitions need not be committed to memory but should be thoroughly digested so that the distinction between the different units will be grasped and a working knowledge of what each stands for and the quantity it represents will be obtained. Very few electrical engineers or electricians could offhand give a basic definition of the ampere*, although they might all know that it is a measure of

* The ampere is defined technically as the practical equivalent of the unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with standard specifications, deposits silver at the rate of 0.001118 gram per second.

rate of flow of electric current and have a practical conception of the magnitude of the unit. In dealing with illumination measurements it is more practical to have a conception of the quantity of light represented by one lumen, than it is to be able to tell precisely what a lumen is. Obviously, it is of advantage to standardize certain units so that relations of magnitude can be expressed and understood with precision, although the value we arbitrarily assign as a standard is of little importance except from this standpoint.

The Candle.

A generation or two ago, when new light sources began to supersede the candle, it was most natural that the illuminating power of these new sources should be expressed in terms of the candle familiar to all. It is probable that the very first comparisons of two light sources were made by setting up the two lamps in the line of vision and gauging them by means of the eye, the most natural direction in which to look at the sources being the horizontal.

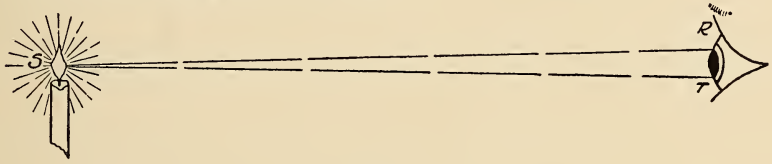


Fig. 1
Only a slender cone of light reaches the eye

A glance at Fig. 1 shows that the eye (an extremely fallible instrument of light measurement at its best) is capable of measuring only a very slender cone of light at one time; in fact, if the eye is an appreciable distance from the source, the cone *RST* becomes virtually a single line.

While there are an infinite number of directions from which the eye might look at the source, the light-giving power in a horizontal direction was made the basis of comparisons, and the strength of the light in this direction from a candle made according to certain definite specifications, was arbitrarily chosen as the unit of intensity and called a candle. The newer illuminants appearing on the scene were rated according to their strength in this same direction and were stated to give so many candles. This rating of an illuminant is made by means of an instrument known as a photometer, a description of which will follow later. One essential point to remember in this connection is that the candle-power of a lighting unit represents the intensity in one direction only. In practice it has been customary for years to rotate the illuminant about a vertical axis while the candle-power was being determined and the result was known as the mean or average horizontal candle-power but even this determination gives an average value of the intensity in the horizontal direction only.

To carry our conception of candle-power a little further, let us assume three conditions.

In the first case (Fig. 2A) we have on the left a standard candle and on the right a photometer pointed toward the candle. From what has

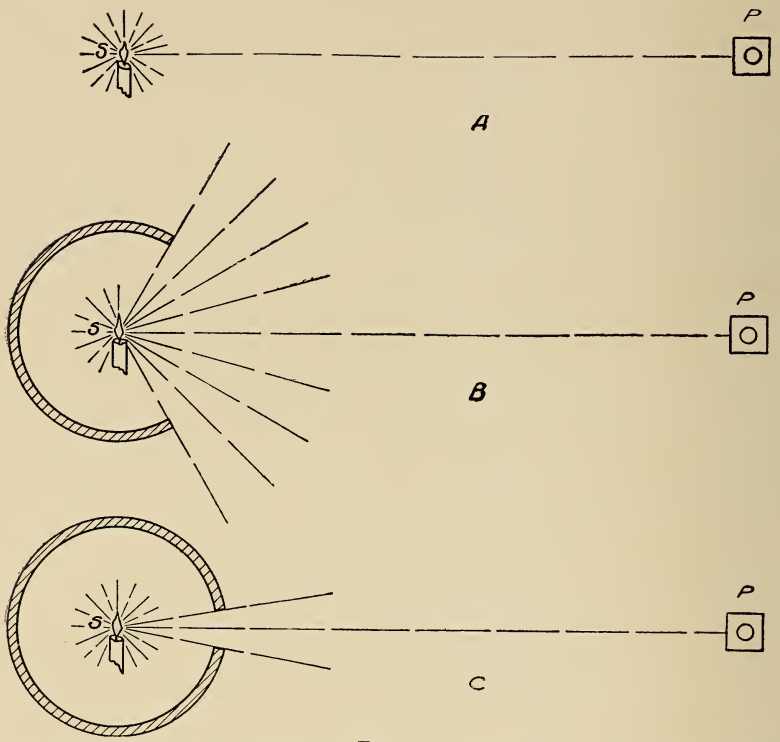


Fig. 2
The candle power in the direction of the Photometer is not changed by partially surrounding the light source with a non-reflecting surface.

already been stated, it is obvious that when the photometer is balanced it will indicate an intensity of 1 candle.

In the second case, (Fig. 2B) we have used a sphere with a much smaller opening and are, therefore, wasting still more of the light, but even in this case our photometer will indicate an intensity of 1 candle. In fact, our reading will be 1 candle regardless of the size of the opening, that is, regardless of the quantity of light we allow to be emitted, provided the direct rays from the candle to the photometer are not obstructed. This leads us to the important conclusion that the candle-power of a source gives no indication of the total quantity of light emitted by that source. Candle-power, we may say, is analogous to a measurement of the depth of a pool of water at a certain point on its surface—a measurement which is useful for certain purposes, but in itself gives no indication of the quantity of water in the pool.

The first fundamental concept we have to deal with in illumination, then, is candle-power, which is the measure of strength of a source to produce illumination in a given direction, and the power in a horizontal direction of a candle made according to certain specifications and burning under certain conditions has been arbitrarily chosen as the unit for measuring this strength.

Closely related to candle-power is mean spherical candle-power. The mean spherical candle-power of a lamp is simply the average of all the candle-powers in all directions about that lamp.

The Lumen.

We have seen that candle-power alone gives no indication of quantity* of light. It is necessary, therefore, for us to develop a unit whereby we can measure the quantity of total flux of light emitted by a source.

For this purpose let us assume a source giving one candle in every direction, and that this source is placed at the center of a sphere painted black on the inside and having a radius of, say, 1 foot,

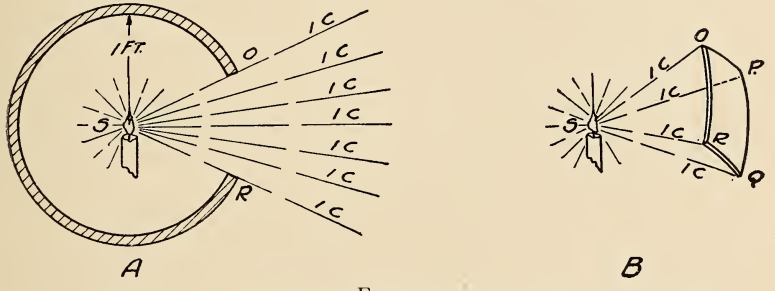


Fig. 3

Opening *OR* has area of 1 square foot and emits 1 lumen; B One lumen falls on surface *O P Q R*

(Sketch A, Fig. 3) *OR* represents an opening in the sphere through which some of the light may escape. The quantity of light allowed to escape may be varied by varying the size of the opening, with the candle-power of the source and the radius of the sphere remaining fixed; if we decide on some definite size of opening at *OR* we shall have a definite quantity of light which we can use as our unit for measuring quantity. The simplest area or unit to assume for *OR* is 1 square foot, and if we do make this opening of an area of 1 square foot, the amount of light that escapes is considered to be the unit of quantity, and is called a lumen. †Thus we have established a permanent unit for the measurement of quantity of light; the mathematical relations used to fix it serve only the same purpose as two scratches on a platinum-iridium bar in the International Bureau of Weights and Measures, the distance bweteen which at a definite temperature is called a meter.

If the area of *OR* is made ¼ square foot, the light escaping will amount to ¼ lumen; if the area of *OR* is doubled, the light escaping will be 2 lumens. On the other hand, if we have a uniform source of 2 candles instead of 1, 2 lumens will be emitted through an opening of 1

* Quantity is here used in the sense that it indicates only a summation of flux as throughout a given solid angle about the source, and over a given area illuminated to some average value. Quantity in a more precise sense is a summation over a period of time and is measured in lumen-hours.

† We could choose a sphere of any radius we cared to, as long as we kept the proportions the same by making the size of the opening such that its area would be equal to the square of the radius. The quantity would still be one lumen.

square foot in this particular sphere. We know by arithmetic that the total surface of the sphere having a radius of 1 foot is 12.57 square feet. In other words, removing the sphere entirely, we would have the equivalent of 12.57 openings the size of *OR;* that is, if the candle gives 1 candle in every direction, with the sphere removed it would give 12.57 lumens. This means that if we know the mean spherical candle-power of a source by multiplying this value by 12.57 we obtain the number of lumens emitted by that source. A lumen may also be defined as being equivalent to the quantity of light intercepted by a surface of 1 square foot every point of which is at a distance of 1 foot from a source of 1 candle. (Fig. 3, Sketch B).

While the foregoing definitions establish definitely the quantity of light that we use as our basic unit, it must be remembered that a lumen, in order to be a lumen, need not necessarily conform with these specifications if the quantity of light represented is equivalent to that prescribed by the definition. A bushel might be defined as the quantity of any commodity contained in a cylindrical measure having a diameter of 13½" and a height of 8"; however, a bushel of potatoes spread out in the field is just as much a bushel as though the shape of the pile conformed in every respect to the dimensions just mentioned.

A conception of the relations just discussed may be obtained from the following simple analogy: Suppose that we have a pool of water of unknown depth, whose area has been found to be 5000 square inches, and it is desired to obtain a measurement of the quantity of water in the pool. At first thought, one might be tempted to measure the depth at some point by means of a yardstick. If, for example, the depth at this point were found to be 6 inches, he might say that the pool contained 6 inches of water. Obviously, such a measurement would be practically useless. A measurement of this sort corresponds to the measurement of the quantity of light given off by an illuminant as determined by its candle-power in a single direction. On second thought, the investigator might make determinations of depth at regular intervals along a straight line through the center of the pool from edge to edge and find the average depth along this line to be, say, 4 inches. To say that the pool contains 4 inches of water would hardly be more conclusive than the first determination. Such a measurement would correspond to the mean horizontal candle-power of a light source. If the surface of the pool were divided into a large number of equal squares and measurements of depth made at the center of each square, the average depth thus found would give a definite idea of the quantity of the water in the pool since the surface area is already known. This determination corresponds to mean spherical candle-power. Now, if the average depth of the pool as just determined, is, say, 4½ inches, the quantity of water in the pool is 4½ times 5,000 or 22,500 cubic inches. To say that the pool contains 22,500 cubic inches of water is definite and positive, and this measurement corresponds to the number of lumens given off by a light source. The average depth of the pool corresponds in this analogy to the average intensity of the light source in all directions and the area of the pool corresponds to the area of the imaginary sphere about the light source.

It might be said that the above method would be a very awkward

one to employ in determining how much water there is in the pool. A more practical method would be to pump the water into some measuring vessel, as, a barrel graduated in gallons. As a matter of fact, measuring the total lumens emitted by a light source is performed in a manner analogous to the method just referred to. The mean spherical candle-power or the lumen output of an illuminant may be determined at one reading by means of an instrument known as a sphere photometer.

The Foot-Candle.

Light is a cause and illumination the effect or result. Both the lumen and the candle are used to measure the cause, these units applying to the light source itself and not to the point where the light is utilized. To measure the illumination on a newspaper, desk or on a motion picture screen, we employ a unit called the foot-candle. A foot-candle represents an intensity of illumination equal to that produced at a point on a plane which is 1 foot distant from a source of 1 candle and which is perpendicular to the light rays at that point.

In Fig. 4, if the source S gives an intensity of 1 candle along the line SA and if A is 1 foot distant from the source, the intensity of illumina-

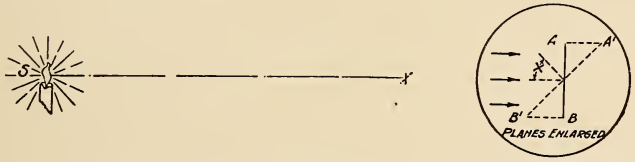


Fig. 5
The Illumination is less on A′B′ than on AB (see footnote)

tion on the plane CD at the point A is one foot-candle.* The intensity of illumination, measured in foot-candles, is the unit of measurement most intimately associated with our everyday use of light, and a measurement which the eye either consciously or unconsciously is making whenever the faculty of vision is being employed, for the number of foot-candles we have on the screen, other things being equal, determines directly whether or not there is sufficient light.

A working idea of a foot-candle of illumination can be obtained by considering the intensity on a newspaper being read by the light of a candle, the paper being held approximately one foot away from the candle. The foot-candle is a unit applying to a point on a surface; by averaging the foot-candles at a number of points on a plane, we get the average intensity of illumination on that plane.

Care should be taken to avoid confusing the intensity of illumination on a surface as indicated by the foot-candles with the appearance

* If instead of being perpendicular to the beam, the plane AB is tilted at an angle, as shown in Fig. 5, it will be seen that the light of this beam is spread over a greater area than if the plane is perpendicular, so that the intensity of illumination on the plane is less in proportion to the ratio of the length of AB to the length of $A'B'$, or to the cosine of the angle between a perpendicular to the $A'B'$ and the axis of the beam, which is the angle X. If, with the plane in the position AB the illumination is 1 foot-candle and the cosine of the angle X is 0.7, the average illumination on the plane in position $A'B'$ will be only 0.7 of a foot-candle.

as regards brightness of the surface. For example, a dusty or dirty screen lighted to an intensity of five foot-candles will not appear so bright as a white one, for a greater proportion of the light falling upon the screen is absorbed and lost. The brightness of an object depends upon both the intensity of illumination on it and the percentage of light that it reflects.

Having defined the foot-candle as a unit of intensity of illumination, we are naturally interested in seeing how the intensity of illumination varies as the candle-power of the source varies, and also as the area over which a given beam is spread varies. It is obvious that if, in Fig. 4, instead of an intensity of one candle along the line *SA*, we have an intensity of two candles, the illumination at '*A*' would be twice as great, and that if we have an intensity of five candles the illumination at '*A*' will be five times as great. Now, if we consider a source of one candle as shown in Fig. 6, we know that the intensity of illumination on '*A*' which is one foot distant is one foot-candle. If, however, we remove the plane '*A*' and allow the same beam of light that formerly was intercepted by '*A*' to pass on to the plane '*B*,' two feet away, we find as shown in the diagram that this same beam of light would have to cover four times the area of '*A*'; and, inasmuch as we cannot get something for nothing, we would find that the average intensity on '*B*,' two feet away, would be one-fourth as high as that on '*A*' 1 foot,

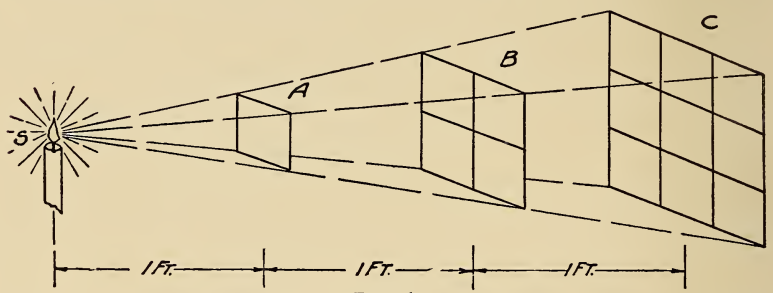


Fig. 6

The Illumination on a surface varies inversely as the square of the distance from the source to the surface.

away, or one-fourth of a foot-candle. In the same way, if '*B*' also is removed and the same beam allowed to fall upon plane '*C*,' three feet away from the source, it will be spread over an area nine times as great as '*A*,' and so on; at a distance of five feet we would have only one-twenty-fifth of a foot-candle. From this we deduce that the intensity of illumination falls off not in proportion to the distance ,but in proportion to the square of the distance. This relation is commonly known as the inverse square law.

Important Relation Between Foot-Candle and Lumen.

If we refer back to Fig. 3B, we see that the surface *OPQR* is illuminated at every point to an intensity of one foot-candle. We also know by definition that the quantity of light falling on the plane *OPRQ* is one lumen. This gives us the important law that if one lumen is so

utilized that all of the light is spread over a surface of one square foot, that surface will be lighted to an average intensity of one foot-candle. This relation is an important one for once the number of square feet to be lighted and the intensity of illumination which it is desired to provide are known, it is a simple matter to find how many lumens must be supplied to the surface. If, for example, it is desired to illuminate a surface of 100 square feet to an average intensity of five foot-candles, 500 lumens must be utilized.

Photometry

Photometry is a specialized branch of the science of illumination which in itself may be made the subject of an extended study. The man doing field work in illumination has no need for an intimate knowledge of all the details that enter into this branch of the art. In the following discussion, photometers are treated in a broad, general way and for more detailed description of the instruments, the reader is referred to standard works on the subject of illumination and photometry.

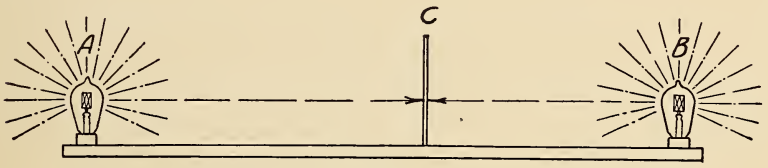


Fig. 7
Essential Parts of Horizontal Photometer

A sketch of the most simple type of photometer is given in Fig. 7. The essential part of this photometer is a vertical paper screen between the lamps to be compared, at the center of which is a grease spot. When the illumination on one side of the screen is greater than that on the other, the spot will on this side, appear darker and on the other side lighter than the surrounding paper. By sliding the screen back and forth on the bar, a position can be found where the outlines of the spot will vanish and the spot itself will disappear. When this condition obtains, the illuminations on both sides of the screen are the same.

In order that both sides of the screen may be seen simultaneously, mirrors are mounted obliquely behind the screen. In Fig. 8, Case A, it will be noted that the spot as viewed in the left-hand mirror is darker than its surroundings and as viewed in the right-hand mirror is lighter than its surroundings, which indicates that the left-hand side of the screen is illuminated to a higher intensity than the right. In Case B of the same figure, it will be noted that the conditions are reversed; therefore, in this case the illumination on the right side of the screen is greater than that on the left. Somewhere between these two positions is a position at which the spot will cease to be visible, as shown in Case C of Fig. 8.

From what has been said above, the intensities of illumination on both sides of the screen in Case C are equal. Now, since we have a re-

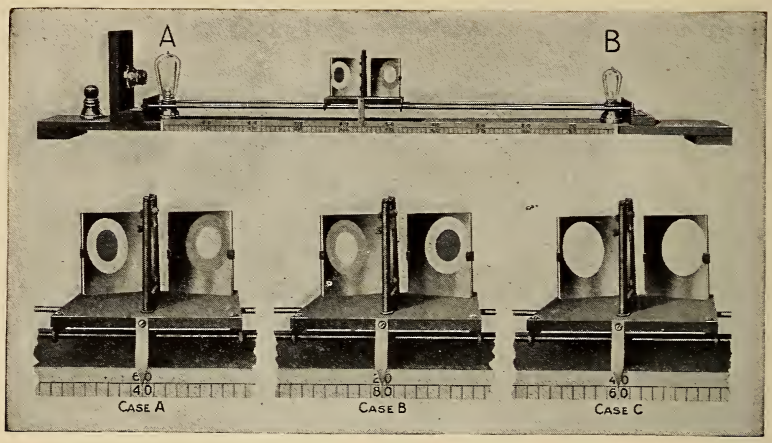


FIG. 8
PHOTOMETER AND SCREENS
Case A—Screen at left of balance point
Case B—Screen at right of balance point
Case C—Screen at balance point

lation between the intensities of illumination that the two lamps being compared are able to produce, we can reason back as to the relation between the candle-powers given, respectively, by lamps *A* and *B* (see Fig. 8). The scale of the photometer shows us that at a distance of 60 inches the lamp *A* produces an illumination equal to that which the lamp *B* can produce at a distance of 40 inches. At first thought we might say that *A* must give $\frac{3}{2}$ as great a candle-power as *B*, but recalling the inverse square law referred to on page 14, which states that the intensity of illumination varies inversely as the square of the distance, or what is the same thing, that the candle-power necessary to produce a given illumination varies as the square of the distance from the source of the plane, we see that the ratio of the candle-power of *A* to that of *B* instead of being 3 to 2 is 3^2 to 2^2 or 9 to 4. The horizontal candle-power of *A*, therefore, is 2¼ times that of *B*. If *B* is a lamp of some known candle-power, the candle-power of *A* is determined by multiplying the candle-power of *B* by 2¼. The general rule, then is that the candle-power of two lamps on a photometer are to each other as the square of the distances from each to the screen are to each other. For accurate photometry, the grease spot screen is no longer in use, but the newer and more accurate photometers are the same in principle.

The simple bar photometer measures candle-power in one direction only. If the lamp being measured is rotated about its vertical axis, its mean horizontal candle-power is obtained. In like manner, if the vertical axis of the lamp being measured is tipped and the lamp rotated on this axis, the average candle-power at any angle can be determined.

An instrument called the foot-candle meter as mentioned last year, has been designed to measure foot-candle intensities quickly and with

a fair degree of accuracy. It is very simple in operation, so light that it can be easily carried about, and so small that readings can be taken in very restricted spaces. The instrument is shown in Fig. 9. In operation, it is placed upon or adjacent to the surface on which a measurement of the foot-candle intensity is desired. A lamp within the box illuminates the under side of the photometric screen to a much higher intensity at one end than at the other. The illumination which it is desired to measure is, of course, practically uniform over the entire scale. Closely spaced translucent dots, which serve the same purpose as the grease spot in the simple bar photometer, line the scale from end to end. If the illumination on the scale from the outside falls within the measuring limits of the meter (0.5—25 foot-candles) the spots will appear brighter at one end of the scale than at the other, and at the point where the spots are neither brighter nor darker than the white paper scale the illuminations from within and from without are equal. The scale is accurately calibrated with the lamp within the

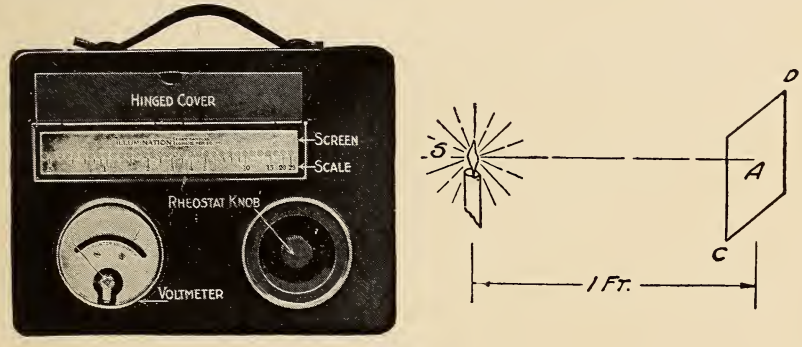


Fig. 9
Foot Candle Meter

box burning at a certain definite voltage. A voltmeter and rheostat permit the operator to adjust the lamp voltage to that at which the instrument was originally calibrated. The energy is supplied from small dry cells.

This instrument is proving very serviceable for "checking up" installations to insure, for example, that the illumination is ample when the projection equipment is in first-class shape and to see that it is not allowed to fall below a desirable value due to improper care and attention being given to the system. This instrument is of special value in securing data which can be applied in the designing of future installations.

The three units which have been discussed at length, the candle, the lumen and the foot-candle, will find wider and wider usage in the motion picture industry as their meanings become better understood. A discussion of light sources, for example, involves a discussion of intrinsic brilliancy (which means candle-power per square inch of luminous area) for upon the intrinsic brilliancy of a source depends in large measure its effectiveness in light projection. It involves a dis-

cussion of candle-power distribution of light, for upon this depends in large measure the design of the optical system. It involves a discussion of lumens output per unit of power input, for the source we use must be acceptable from the standpoint of light produced for energy consumed.

A discussion of the efficiency of optical systems involves the use of the unit of light flux, the lumen.

A discussion of screen illumination involves the use of the term lumen for expressing the total light flux reaching a screen, and the term foot-candle for discussing the distribution of the light flux over the area of the screen. The brightness of the screen involves, also, the term candle-power.

A discussion of theater lighting involves the terms candle-power, foot-candle, and lumen. The candle-power per unit of source area must be low in order that glare will be avoided, the foot-candle intensity must be sufficiently high to permit obstacles to be avoided, and the lumen output of the lamps must be sufficient to provide the proper foot-candle intensity.

As I have pointed out, the definitions are simple once their meaning and purpose are thoroughly understood. The following definitions have been accepted by many technical societies throughout the country.

Candle-Power—(C.P.)

The candle-power is the unit in which the luminous intensity of a light source is measured. Measurement of candle-power is not made directly, but is obtained by comparison with that produced by a standard under certain specified conditions.

The present unit of candle-power is referred to as the "International Candle," and is a unit 1.6 per cent smaller than the old "British" or old American candle, which was in use in the United States prior to 1909. The following table gives the relation between the units in use at the present time

1 International Candle=1 American Candle.
1 International Candle=1 French Candle, called "Bougie Decimale."
1 International Candle=1 English Candle, called "Pentane Candle."

If the intensity be measured in all directions in a plane perpendicular to the axis and passing through the center of the filament, the average of the values obtained would be called the mean horizontal candle-power. The axis of an incandescent lamp is assumed to be a line connecting the center of the base and the tip of the bulb.

The average of the candle-power intensities in all possible directions from the source is known as the mean spherical candle-power. Rating in terms of mean spherical candle-power is of supreme importance in comparing lamps having differently shaped filament. The mean spherical candle-power bears a definite relation to the total flux of light, and is, therefore, sometimes used as a measure of that quantity. The mean horizontal candle-power can not satisfactorily be used to indicate the light output of other than vacuum incandescent lamps and lamps without concentrated filaments; because of this limitation it is being superseded by ratings dependent directly upon the total light emitted. (See definition of "Lumen.")

Foot-Candle.

The intensity to which a surface is illuminated is measured in foot-candles. The intensity of illumination can be measured by a photometer or it can be calculated when the candle-power, direction and distance of the light source or sources is known. The illumination produced by a source of 1 c.p. on a perpendicular plane 1 foot away has an intensity of 1 foot-candle. When one lumen of flux uniformly covers 1 square foot of surface, the surface is illuminated to an intensity of 1 foot-candle.

$$\text{Foot-candles} = \frac{\text{CPX-Sine } \Phi}{D^2}$$

The c.p. is that of the source in the direction of the surface considered the angle is the angle between the light-ray (when the surface is perpendicular to the ray of light, the angle Φ is 90 degrees and sine I is 1.00). *D* is the distance in feet from the source to the surface.

This relation holds exactly only when the source dimensions are small compared with the distance of measurement.

Lumen.

The lumen is the unit of light flux. The flux required to light a given surface is proportional to the illumination and to the area of the surface. One lumen will light a surface of 1 square foot to an average intensity of 1 foot-candle. The number of lumens required to light a surface to any given illumination is equal to the product obtained by multiplying the area of the surface in square feet by the average foot-candles which it is desired to produce. Since a foot-candle of illumination is produced by a source of 1 c.p. shining on a surface one foot distant, if a source giving 1 c.p. in every direction is at the center of a hollow sphere of 1 foot radius every point on the interior surface of the sphere will be illuminated directly from the source to an illumination of 1 foot-candle. As the interior surface of the sphere of 1 foot radius has an area of 12.57 square feet and as the 1 c.p. source directly illuminates this area of 12.57 square feet to 1 foot-candle, the source must produce 12.57 lumens. Consequently a source of an intensity of 1 c.p. in every direction, which is 1 spherical candle-power, has an output of 12.57 lumens.

In view of their usefulness in the study of light projection, I suggest that these definitions be incorporated in the Standards of this Society and that this Society make an earnest effort to popularize them in the motion picture industry.

ADVANTAGES IN THE USE OF THE NEW STANDARD, NARROW WIDTH, SLOW-BURNING FILM FOR PORTABLE PROJECTORS

By W. B. Cook

At the last meeting in April at Rochester, your Society adopted a new size of narrow width, slow-burning film as the standard for all portable projectors. As the firm with which the writer is connected has had nearly five years of successful experience with a similar product, the Chairman of your Papers Committee has requested me to prepare and submit to you some actual facts of the advantages pertaining thereto.

Safety First

We owe a profound debt of gratitude, which will be better appreciated in later years, for the high and noble motives which actuated the sponsors of the new standard and also those members of your Society who co-operated so earnestly in the adoption of a standard which is designed to remove the portable projector industry from a severe and menacing cloud of public mistrust and legislative restriction.

The clearly recognized hazards of the use and even the storage of celluloid film have been not only pointed out by the Underwriters' Laboratories, but have been by them so insistently urged that not only the States, but practically all important municipalities have been compelled to surround the use and storage of celluloid films, within their jurisdiction, with such wise and protective restrictions as would tend to reduce to a minimum the hazards to which the members of the Commonwealth are constantly subjected in attending public or private cinematograph exhibitions.

In the last few years the growth and expanding fields of usefulness of the motion picture have surpassed the wildest imagination of its earlier advocates.

It has long been obvious that a medium of such wonderful educational value would inevitably be recognized as an essential for public instruction as well as entertainment. Progressive schools, churches and institutions have been quick to realize that in the motion picture lies one of the best aids to their usefulness.

It very soon became evident that the principal drawbacks to the general adoption of the motion picture in school, church and institutional work were the expense of the standard theatrical projectors, the specialized skill and knowledge required in their operation, and the deplorable lack of film subjects suitable for institutional use.

The first and second objections were sought to be overcome by the manufacture of cheaper and simpler forms of portable projectors, which could be easily carried from one room to another instead of being limited to a single auditorium, and whose simplicity of construction and operation would enable them to be operated by persons of very moderate mechanical skill.

But our very efficient guardians of life and property—the Insurance authorities—promptly pointed out that the principal hazard attendant upon such exhibitions lay, not in any hazard or use in the projector itself, but in the use and storage of the celluloid film used as a medium therein. The very advantages claimed in the use of the portable projector, namely, use without a booth and by people of limited mechanical skill, tremendously increased the film hazard beyond that attending its use in the standard machines enclosed in fireproof booths and under the operation of skillful attendants.

The obvious solution of the problem of hazard lay in the adoption of approved, slow-burning film, but the Underwriters' Laboratories again pointed out that unless the portable projector should be so constructed that it would be impossible to use ordinary celluloid film therein, it was a foregone conclusion that in the absence of any considerable quantity of available slow-burning film, the owners of such projectors would be sure to attempt the use of celluloid films therein (if such use should be possible) and the potential hazard would still remain exactly as before.

To cover the situation properly, the Underwriters' Laboratories suggested, and the National Association of Fire Prevention adopted the specific qualification:

"Approved miniature projectors must be so constructed that they cannot be used with films employed on the full sized commercial moving picture machine." (National Electric Code—Rule 38, Section V, Paragraph 6).

Various attempts have been made to comply with this requirement, such attempts being principally confined to the use of some form of odd perforation for standard width, slow-burning film, to fit a sprocket so constructed that it would mutilate ordinary celluloid film of standard perforation.

None of these attempts have met with any practical success and all of them are open to the serious, if not insurmountable objection that in the hands of any ordinarily intelligent but unscrupulous owner the mutilating sprocket could be very easily exchanged or altered so that it will run standard celluloid film.

Only Satisfactory Solution Is Adoption of a New Standard With Different Width and Perforation

Anything less than this is obviously not deserving and therefore cannot hope for permanent success.

It is only through the fact that the buyers are ignorant of the Underwriters' code and the criminal risk involved that they now purchase and use small portable projectors employing inflammable film. This intolerable condition has greatly retarded the natural expansion of the portable projector industry and the sooner we unite in removing it, the quicker will we enjoy the benefits of a healthy growth and expansion.

One manufacturer as long as seven or eight years ago took the lead boldly by adopting both an odd size and an odd perforation for use exclusively with slow-burning film, with the idea of insuring a thoroughly safe and approved apparatus.

This odd-sized machine and its film were, of course, regarded as an outlaw and suffered from the combined attacks of all other manufacturers of portable projectors designed to use the ordinary celluloid film.

In spite of the fact that the early users of the odd-sized machine were limited to the use of a very restricted repertoire of available subjects; in spite even of the fact that the earlier models of the machine had rather narrow limitations as to size and brilliance of picture, it has achieved some measure of success, as evidenced by the simple fact that more than ten thousand of them have been sold and are used all over the world, and more than 25,000,000 feet of printed positive on slow-burning stock has been made therefor.

The only possible explanation of this success lies in the fact that it was something that the public wanted. But why did they want it? At every stage of its career, this odd-sized machine has been exposed to the keenest individual and collective competition of all makers of portable projectors using standard celluloid film.

The answer requires but one word—*safety*.

If *safety* were the single and only advantage to be derived from this adoption of the new width and perforation, it would still be more than amply justified. But there are also other good and important advantages inherent therein. As a matter of fact, the adoption of the new standard is not merely a matter of business policy, but as pointed out above, it is an imperative necessity for the self-preservation and insured permanency of the portable projector industry. Anything short of a real approved projector is regarded as dangerous by the insurance, State and Municipal authorities and the user thereof with celluloid films is regarded as a menace to public safety.

Having decided that the industry absolutely required a new standard width and perforation, your Society naturally and wisely adopted one that makes immediately available some 25,000,000 feet of existing positive stock and also the facilities of several established plants for the further production of additional films, as they may be required.

Economy In the Use of the New Standard

In these days of increasing cost of materials, the item of economy is certainly one to be seriously considered.

The Eastman Company have been furnishing the new standard narrow-width at 80% of the cost per foot for ordinary width. Furthermore, the new standard narrow-width film will contain twenty pictures per foot instead of the sixteen of the present celluloid film. These two factors result in a combined economy or saving of 36% in the cost of stock for any given production. There is also, of course, a very considerable saving in the use of chemicals for developing, and also in the general handling and transportation of the narrow-width film, of which 800 feet in length is equivalent to the ordinary 1,000 foot celluloid reel.

Durability

Film experts seem to fairly well agree that the present deterioration in use of ordinary film is greater than it would be if the perforations were less numerous. In others words, that standard film is weakened

and its life is shortened by having so many as four perforations to each picture. The new standard with three perforations to each picture length would seem to be a logical improvement.

In conclusion and in simple justice to the firm which I represent, some pertinent facts should be made public.

Since the adoption of the new standard at your last meeting, some adverse criticisms have been launched by parties who pretend to see in the new standard a menace to their own self interests.

To an unprejudiced judge, it would seem that the only firm really entitled to complain of the adoption of the new standard would be the one that I represent, in that such adoption virtually wipes out and destroys in one instant a practical monopoly in a certain field, which had existed for a number of years. Your action in adopting the new standard was totally unexpected to us, and in fact it was nearly two months after its adoption before we ascertained definitely that it corresponded sufficiently to our product to take away the exclusive use of our most valuable feature.

Notwithstanding this blow to our own interests, and realizing broadly that the welfare of the industry as a whole infinitely exceeded that of any individual manufacturer, we at once communicated with the officers of your society and later with several of the prominent manufacturers of portable projectors, expressing our willingness to lend our co-operation in every way possible to those interested in the adoption of the new standard.

We herewith publicly offer to and through your Society of Motion Picture Engineers, all the facilities of our organization for the use of any other manufacturer of portable projectors.

Our Technical Department will furnish any dimensions or data as to the sizes of sprockets, film gates, aperture masks, etc., which our own rather extensive experience has enabled us to collect. Our Manufacturing Department will furnish to any other manufacturer any parts which may be of assistance to him in the more speedy adoption of the new standard than would be otherwise possible if each manufacturer were necessarily compelled to make such parts for himself.

We will perforate Eastman narrow-width, slow-burning stock with the new standard perforation for any film manufacturer that desires it.

Finally, our Laboratory and those of our Agencies will make reproductions from standard negatives or positives to the new narrow standard for any users of the new standard portable projectors.

Discussion

After Mr. Cook's paper, Mr. De Vry contributed some discussion to show that the use of non-flam stock for large standard film would make for safer general conditions, and would be more practical than to have two standards—one flam film and one non-flam film standard. He used as the basis of his remarks, the experience in France, and said that if interest enough were shown in the United States, it would be possible to obtain non-flam stock in quantities, as good as the present flam film.

Mr. Cook stated that the law passed in France, referred to by Mr.

De Vry, never became operative because it was postponed every date at which it was to become operative, by representations of the industry that it would be confiscatory to. The theatres in France today are running the same films as used here, because they find it impractical to sacrifice interests, which in France are infinitesimal in comparison to the vast interests in this country.

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